Rural Livelihoods and Access to Resources in Relation to Small Reservoirs: A Study in Brazil’s Preto River Basin

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ABSTRACT

Given the United Nation’s Millennium Development Goals of reducing poverty and improving livelihoods, and the water policy arena’s increased interest in the use of decentralized water systems and community-based natural resource management, the time is ripe to consider the potential of small-scale reservoirs in improving livelihoods of the rural poor. In this paper, I assess this potential. In doing so, I incorporate Guijt and Thompson’s (1994) recommendations that before considering the current and potential roles of small-scale irrigation systems, such as small reservoirs, scientists and planners must consider broader social contexts, and how small reservoirs fit into rural people’s livelihood strategies.

Using data from semi-structured interviews with farmers and institutional representatives in Brazil’s Preto River Basin, I describe the physical and social aspects of small reservoirs, and assess the current role of small reservoirs in the lives of small-scale rural farmers. Then, drawing on this assessment I consider the potential role that small reservoirs could play for communities that do not have such systems. My results and analysis lead to four main findings:

1. The socio-physical system of small reservoirs allows for year-round irrigated agriculture for some farmers, and leads to the subsequent production and sale of, as well as the generated income from vegetables. In addition, the system provides for multiple uses (i.e. agricultural, domestic and livestock purposes), which allow for multiple benefits (i.e. economic, nutritional and vulnerability reduction).

2. Despite these economic and non-economic livelihood benefits, not all farmers within a community have access to small reservoirs and their derived benefits. In particular, unequal access to water supplied by these systems results in unequal access to these livelihood benefits.

3. Benefits from small reservoirs not only depend on distribution of the water supply and the physical system, they depend largely on a community’s potential and realized ability to access critical institutional, financial and social resources.

4. Communities that do not have small reservoirs have significant domestic and drinking water shortages, as well as significant shortfalls in accessing institutional and financial resources necessary for community development and the use of small reservoirs.

These results underscore the need to consider access to both the reservoir systems within a community and to broader sets of resources within and outside of communities, alongside considering livelihood benefits. In sum, farmers can derive livelihood benefits from small reservoirs, but only if access to water and necessary resources are available.
INTRODUCTION

Current research on small reservoirs asks: can small reservoirs improve the livelihoods of the rural poor (SRP 2006)? Given the United Nation’s Millennium Development Goals (MDGs) of reducing poverty and improving livelihoods, and the water policy arena’s increased interest in the use of decentralized water systems and community-based natural resource management, the time is ripe to answer this question. Nevertheless, theories on poverty (Sen 1981) and access to benefits from resources (Ribot and Peluso 2003) suggest that researchers should also ask: how does access to resources determine whether livelihood benefits are possible? The goal of this paper is to address both questions.

To contextualize the aforementioned questions, it is important to first look at present day goals of the international development arena. Perhaps most broadly relevant are the MDGs. In 2000, world leaders convened to set clear targets for reducing extreme poverty in its many forms—poverty, hunger, disease, illiteracy, environmental degradation, discrimination against women, etc. (United Nations 2005). Given these targets for improving the lives of the poor, the question of whether small reservoirs can improve livelihoods of the poor is relevant.

Beyond the MDGs, a newer approach in the international development arena has particular relevance. Promoted most strongly by the United Kingdom’s Department for International Development (DFID), an increasing number of development policies aim to assess the impact of development projects on sustaining livelihoods (Scoones 1998). Drawing partially on Sen’s (1981 and 1984) promotion of looking at human capabilities and entitlements, as well as Chambers’ (1995) recommendations to look at the impact of development on human well-being, the sustainable livelihoods approach, though loosely defined (Scoones 1998), aims to look at the impact of development projects on: 1) creation of working days, 2) reduction of poverty, 3) well-being, 4) adaptation, vulnerability reduction and resilience, and 5) natural resource base sustainability. Building from this framework, this study is particularly concerned with what the impact of small reservoirs is
on the livelihoods of the poor in terms of reducing poverty, increasing overall well-being, and reducing vulnerability of marginalized populations.

The question of the role of small reservoirs in rural livelihoods is also motivated by debates on decentralized water management and community-based natural resource management. Despite the fact that both debates have received a range of critiques, both have a dominant role in the current water policy paradigm. The former, supported mainly by both neo-liberal philosophies that argue that decentralized services are more efficient than centralized ones, and more green philosophies that stress lower environmental impacts relates to the question because it suggests focusing on more independent and decentralized water management in rural areas. The latter, supported increasingly in the wake of the United Nations Conference on Environment and Development (UNCED) implies that sustainable development should be based on local solutions and implemented by communities (Leach et al, Ghai and Vivian 1992). In both of these contexts, this study’s motivating questions are relevant as they can potentially address the degree to which decentralized, locally-managed water supply schemes are successful.

Within this policy context a consideration of small reservoirs and their potential role in impacting rural livelihoods and poverty is particularly poignant. In Latin America, Asia and Africa, small1 reservoirs are oftentimes a part of small-scale irrigation systems that are used in rural areas, both by industrial-scale farmers and rural farming communities. Often designed as earthen dams along a stream, small reservoirs are units that help store water, buffer the effects of variable rainfall, and offer multiple uses of water (i.e. drinking, agricultural, livestock) (Turner 1994) for nearby water users.

Beyond this general policy context, the development arena and related academic literature have given small reservoirs increased attention. While small-scale irrigation systems, such as small

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1 While “small” can be defined by surface area, volume, type of management, and multiple other variables (Turner 1994), this study uses current definitions in the Preto River Basin, and defines small based on surface areas between one and forty-five hectares. In addition, for the purposes of this study, small reservoirs are considered to be those reservoirs which are managed locally, supply water for irrigation or other purposes to farming communities or individual farms, and are less than 45 hectares in surface area.
reservoirs, have been used for millennia, their deliberate promotion as a development tool began only in the last three decades. In fact, from the 1940s through the 1970s, the international development community’s promotion of locally-managed, small-scale irrigation systems was largely overshadowed by support for large-scale irrigation schemes, such as large dams (Vincent 1994). In the 1970s, however, a growing set of critiques began regarding the social and environmental impacts of such large-scale projects. In response, the end of the 1970s saw the beginning of a newer trend, one which has increasingly supported small-scale, locally-managed irrigation systems. The assumption behind supporting these small-scale systems is that they are less environmentally destructive and more appropriate for meeting community-level water needs.

Following this trend, the literature on small-scale irrigation systems has grown accordingly. Here, the literature falls into two loosely-defined camps: one that focuses on the technical performance of small-scale systems, another which focuses largely on the social and institutional aspects of these systems. In terms of small reservoirs, the former has focused largely on questions regarding water-use efficiency, water productivity and crop production (Faulkner 2005, Yoder and Martin 1990, Ambler 1994). The later has tended to focus on questions regarding socio-cultural and institutional management aspects of these small-scale systems (Ambler 1994, Savva et al 2000, Vincent 1994, Coward 1979). Here, the literature has mainly focused on the role of cooperation and institutions in the management of these small-scale systems, and on the common property nature of these systems.

Increasingly, a “third camp” has emerged, one which is related to the aforementioned policy context. This “camp” is particularly concerned with the socioeconomic impact of small-scale irrigation systems, their potential to alleviate poverty and their ability to support rural livelihoods (IWMI 2003, Bhattarai et al 2002). This newest arena, alongside international policy goals has prompted research projects like the Small Reservoirs Project (SRP)—a multi-disciplinary study of the hydrologic and socioeconomic impact of small reservoirs in Brazil, Ghana and Zimbabwe—to assess
the current and potential role of small reservoirs in supporting livelihoods of small farming communities in the Preto River Basin.

Alongside this “third camp” and the aforementioned policy context, the missing frame must be inserted: theories of access. As first put forth by Sen (1981) in his work on poverty and famines, Sen suggested that people command access to food based on the legal means available in society. He noted that a person can starve “because he does not have the ability to command enough food.” Building on this idea, Sen’s entitlements approach analyzed people’s entitlements to commodity bundles, and concluded that starvation happens when there is a failure to be entitled to a bundle with enough food. In a similar vein, but focusing on natural resources, Ribot and Peluso’s (2003) work on theories of access argue that we must look at the bundles of power that people command so as to receive benefits from resources. Together, these approaches are useful for small reservoirs in that they suggest that if we consider whether people are entitled to, or have access to small reservoirs, we may better understand whether people receive benefits from these systems.

Brazil’s Preto River Basin provides an ideal site within which to consider the impact and potential role for small reservoirs in the broader context of livelihoods, socioeconomics and the necessary resources required to receive livelihood benefits. Though small in comparison to the overall São Francisco Basin within which it resides (roughly 10,500 square kilometers versus 639,920 square kilometers), the Preto River basin contains a range of water use dynamics which make it worth studying. Some of these water use dynamics are determined by small reservoirs. For example, some small rural communities have small reservoirs that are used for the production of vegetables, while other communities have no reservoirs and rely on alternative livelihood strategies.

Furthermore, since 2000, large farmers in the region have begun building privately owned small reservoirs to irrigate their crops in the dry season.

These developments have spurred interest in building more small reservoirs for large farmers in the Basin. Given international development goals, this recent interest begs the need to consider the potential role that these small-scale systems can play in alleviating poverty, and/or improving
livelihoods of poorer farmers. Thus, policy makers and scientists have begun to investigate what the hydrologic, socioeconomic and environmental impacts of these systems are.

This study applies Guijt and Thompson’s (1994) recommendations that one look at small-scale irrigation systems, such as small reservoirs, in a broader context. Therefore, this study assumes that to understand the feasibility of small reservoirs as both a form of water supply for multiple uses and a poverty alleviation tool in rural communities, rural livelihoods, broader community institutions, and water use dynamics must be considered in unison. Thus, this study asks three inter-related questions:

1. To what extent do small reservoirs currently contribute to the livelihoods of rural communities?

2. Given current and potential community characteristics, what role could small reservoirs play in the future, both for communities that currently have small reservoirs and for communities that do not?

3. How does access to resources determine whether individuals or communities receive, or could receive these livelihood benefits?

In order to answer these questions, this study collected and analyzed primary data from household interviews in communities with and without small reservoirs, institutional interviews and field observations.

Structure of the Paper

This paper has six parts. Chapter 1 describes the methods used in this study. Chapter 2 describes the study area and small reservoirs in the Basin. Chapter 3 applies a sustainable livelihoods framework (Scoones 1998) to assess the extent to which small reservoirs currently play a role in the livelihoods of rural communities. In addition, this chapter addresses how access to the water supply, as well as to resources and institutions are critical in receiving livelihood benefits. Chapter 4 considers the potential role for small reservoirs, in rural communities that currently do not have small reservoirs. Chapter 5 ends with conclusions and initial policy recommendations.
Target Audience

This study is targeted at two main groups: 1) Water policy and development practitioners in Brazil and the greater international development community, and 2) Researchers expecting to conduct further research regarding socioeconomic aspects and impacts of small reservoirs, especially those researchers working in the Preto River Basin.
CHAPTER 1: METHODS

This study employed four data collection methods: 1) Questionnaires and semi-structured interviews with small and large farmers, as well as institutions, 2) Focus groups 3) Field observation, and 4) Informal interviews.

Baseline Questionnaire for individual farmer/household interviews

I designed one questionnaire to use in semi-structured interviews with farming households. I conducted these interviews with large-scale farming households (ranging from 50-500 hectares, but averaging 350 hectares) and small-farming households (ranging from 1-45 hectares, but averaging less than 10 hectares).

The baseline questionnaire focused on water use, but also included questions on demographics. It included closed and open-ended questions that focused on:

1. General demographics
2. Water use, water quality and access delineation to water
3. Water management and decision-making regarding distribution of water within a community
4. Uses and access to small reservoirs
5. General community characteristics
6. Additional comments presented by respondents

The general demographics section captured basic characteristics such as household size and sources of income, as well as information on basic land-use and agricultural practices, and economics. The “water use, water quality and access delineation to water” had questions on main sources and uses of water, along with characteristics of access and any related problems with access to sufficient quality or quantities of water. The water management and distribution section included questions regarding general water management within the community. The small reservoirs section included questions regarding the history and use of the small reservoirs in communities. The second to last section of the questionnaire asked respondents to comment on the general challenges faced by
the community. Finally, the questionnaire concluded by allowing the interviewee to make general comments.

In small farming communities, the team held interviews with one to several members from a single household. In some cases, for example, the respondent was the male head of household (male or female). In other cases a husband and wife team responded. For large-farm interviews, respondents included either individual owners of the property, or several members of the farm-owner’s family.

**Baseline Institutional Questionnaire**

The study developed a second, shorter questionnaire to interview employees of select government institutions working in rural areas, or on water-related topics. This questionnaire focused on the following types of questions:

1. Type of work done by the interviewee
2. Description of rural communities where he/she works
3. Perspectives on issues regarding water use in rural communities
4. Perspectives on the challenges facing rural communities

**Questionnaire team**

The questionnaires were administered by a three-person team. In the piloting round, one EMBRAPA economist who is an expert in rural questionnaires accompanied us to the field to test our questionnaire. All subsequent questionnaires were conducted by an anthropologist from EMBRAPA, and me. All questionnaires were conducted in pairs, so as to ensure quality of data collection. While one person asked questions, both people took notes. At the end of each interview, the questionnaire team compared notes. Prior to field implementation, the team pilot tested the questionnaires.

**Site Selection: Choosing Communities**

Because one of the aims of this preliminary study was to identify the types of players that exist in rural areas of the Basin, this study deliberately decided against following a randomized
sample framework that would yield statistically significant results. More specifically, the study’s
methodology did not include random sampling because the questionnaire team had no prior field
knowledge of the types of strata by which it would be useful to sample the rural population. Instead,
the team relied on a loose stratification of the region, and on institutional advice to choose
communities and large farmers to interview. After holding informational interviews with researchers
and local organizations in the Basin, we defined preliminary strata for selecting communities. These
were as follows:

1. Large farms that are not a part of small-farming communities, have a mixture of irrigated
   and rain fed agriculture, and use small reservoirs.

2. Farming communities that have small reservoirs, and have at least some members who
   practice either subsistence or subsistence and market-oriented production (e.g. crops, or
dairy)

3. Farming communities that do not have small reservoirs, and have at least some members
   who practice either subsistence or subsistence and market-oriented production (e.g. crops, or
dairy)

Following this loose stratification, the team finalized community sites based on
recommendations from EMATER, the state-level Technical Assistance and Rural Extension Agency
and EMBRAPA. While relying on institutional recommendations can introduce some biases into site
selection, this study deemed the institutional recommendations sufficient, given the following
reasons. First, it is helpful to have some sort of local connection before conducting research in a
community; the institutions provided this connection. Second, this study assumed it would be
useful to hold institutional interviews with organizations that work in the same communities where
we conducted interviews, so as to receive institutional perspectives on these same communities; the
institutions we consulted offered this. Thirdly, many (though not all) of the communities that we
considered focusing on receive some rural support from EMATER, one of the key agencies we
consulted. Finally, because an overarching aim of this research was to reach an understanding of the
region’s players and characteristics through the very process of fieldwork, this study assumed that this would be one of many future studies on water and socioeconomics in the Basin. In this sense, the communities selected were not meant to be representative of all communities, but of a select group of communities. In sum, though the potential for institutional bias in recommending communities is high, it is considered of low relevance for this study.

The interview team selected the communities of Capão Seco, Lamarão, Buriti Vermelho in the PAD/DF region of the Basin, Nucleo Rural Jardim in the Jardim area, and Paraíso, Campo Verde and São João Batista in the municipality of Unai, in the state of Minas Gerais. Each community exhibited a range of characteristics regarding:

1. Land use patterns,
2. Organizations and institutions present,
3. Presence or absence of small reservoirs,
4. Presence of water problems,
5. Proximity to urban areas,
6. Rapid assessment of socioeconomic conditions,
7. Outside institutional opinion.

Respondent Selection

While this study did not employ random sampling in either the selection of communities or households, respondents within communities were purposely sampled based on the following household criteria:

1. Households with and without drinking water supplies;
2. Households located in different areas of the community;
3. Households that use water from small reservoirs, and those that do not; and
4. Households that practice subsistence agriculture and those that do not.
Then the team followed a loose snowball method, where a key informant helped us identify additional households to interview. Seeking respondents from a preliminary list of strata, we sought to include respondents that represented a range of conditions.

Implementation of Farmer Questionnaires

The team conducted 17 household interviews in the seven farming communities and 2 interviews with large farmers. We conducted the latter with an EMATER extension agent. Interviews lasted from 30 minutes to one hour, depending on the length of answers provided by respondents.

Before commencing each interview, we first introduced ourselves as one researcher from EMBRAPA, and one graduate student from the United States. We introduced our research as one focusing on water use in rural communities. We stressed at the beginning and end that this interview would not yield any direct results to the community, but would only form part of a research effort on water in the Preto River Basin. We did not say that one focus of the study was on small reservoirs, so as to minimize respondent bias. At the end of this introduction, we asked for permission to hold the interview.

At the end of each interview, the team gave respondents time to ask us questions and make additional comments. In most cases, people asked how the results of the study would be used. When this was the case, we explained that we were working on a baseline diagnostic of water uses in the Preto River Basin and that some of these results would inform our analysis, as well as future water modeling efforts in the Basin.

Implementation of Institutional Questionnaires

Using the pre-designed questionnaires, the team conducted five institutional interviews: one with an EMBRAPA rural development researcher, one with a water specialist at ANA, two with

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2 In Nucleo Rural Jardim, one landless resident was interviewed. Given that for the purposes of this study, “community members” are defined as those formally included in the original community of Nucleo Rural Jardim. This resident is not included in tabulations regarding community statistics.
EMATER-PAD/DF and one with EMATER-Minas Gerais. These interviews served to span a variety of geographic and institutional perspectives. These interviews typically lasted thirty minutes.

Focus groups

In addition to conducting the interviews with individual farmers, the interview team held one half-day workshop\(^3\) in the community of Campo Verde. During this workshop, the team facilitated several focus groups. Individual focus groups addressed the following themes: 1) Community water resource mapping, 2) Water sources and uses in Campo Verde, and 3) Problems and potential solutions with water in Campo Verde. Data from these focus groups are not included in the lumped analyses of questionnaire results (i.e. statistics), but they are included in general data analysis, and in the general broader regional description.

Field-Site Observations and Informal interviews

In each community that we visited, we spent some time observing daily activities, attending community meetings, etc. This helped contextualize the reality of the community. During field observations, or at the end of questionnaires, the team often employed informal interviews with community members. During these interviews, respondents voluntarily offered background information on the community history, or on the day-to-day challenges which were not specified during the interview. Throughout the informal interview, each interviewer took field notes, and attached them to the larger database, so as to complement the data analysis.

Secondary Data

In Chapter 5, this study relies on secondary data analysis from a 2005 EMBRAPA study. This study was conducted by an EMBRAPA team, one of whose members was interviewed in the institutional interviews. The team conducted a study in twenty-one of the twenty-three resettlement communities in Unaí. Included were the communities of Campo Verde, Paraíso and São João Batista. Part of the study asked community members to list the major challenges they faced in their communities and rank these challenges by voting on them. Each challenge is listed, with the

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\(^3\) While not an original part of field work design, the president of the community organized this day-long event so that all community members interested could be part of the study’s research.
percentage of votes received. I use percentages by community, and relative averages when considering clusters of communities (i.e. the cluster of Campo Verde, Paraíso and São João Batista, etc).

Sources of Error and Uncertainty

As with any questionnaire, the potential for error and uncertainty exists in this study. Specifically, the main potential sources of “error” result in part from the limited sample size, both within communities and for the entire region. This is not taken as a major limitation because part of the goal of implementing the questionnaire was to identify water user groups, and key rural water players in the basin.

It is also important to remember that the descriptions and analyses that come below are based on questionnaire data, informal interviews and observations. Some of these descriptions and analyses are based on what “we saw” and what “we heard”. Here, it should be noted that our perception is not exhaustive, nor is it based on living in the community for a long time. The results should be treated as a diagnostic which is based on outsiders perspectives, and can be updated over time.

Theoretical Note

This paper is not meant to stand alone in terms of defining rural realities in the Basin. This paper is the result of the analysis of over twenty interviews with farmers and institutional representatives in the Preto River Basin. In addition to these interviews, the methods employed by this study were informed by methods of Rapid Rural Appraisal. In combination, this data collection allowed me to look from the outside in, at the role and potential of small reservoirs for poverty alleviation and livelihood sustainability. In line with these results, this paper aims to provide insights for policy and future research. I am of the belief that—as articulated by Robert Chambers’ work on the powerlessness and isolation in poverty and the need for participation in development projects, as well as Paolo Freire’s underlying philosophies that any group itself knows best what it needs. For example, rural farmers understand their realities and needs, and can use this understanding for self-
defined development. Given the time and space to voice their concerns these should be the primary stewards of their communities’ development. Therefore, while this study is aimed to highlight potential needs for rural development, it is not meant to silence the voices of self-defined development as envisioned by the farmers themselves. A large and more comprehensive study would attempt to be more participatory and community led.
CHAPTER 2: STUDY AREA AND SMALL RESERVOIRS

General Characteristics of the Preto River Basin

This study was conducted in Brazil’s Preto River (PR) Basin, a sub-basin of the São Francisco (SF) Basin (Figure 2-1). While the Preto River Basin represents only 1.6% of the total area of the São Francisco River Basin, the dynamics within the Basin are of importance to the greater São Francisco Basin. First, because the Preto River basin captures the increasingly common land-use pattern of expanding the area of irrigated agriculture, a trend that is occurring throughout the upper and middle portions of the São Francisco River Basin. Second, given that the Preto River is the headwaters to one of the main tributaries to the São Francisco Basin, the Paracatu River, land and water-use dynamics in the Preto River basin are of critical importance further downstream. On a socioeconomic level, although the Preto Basin does not include some of the poorest segments of the Basin, as found in Brazil’s semi-arid northeast, broader questions of competing water use dynamics and potential water poverty among rural communities is relevant for the greater basin.

The PR Basin is roughly 10,500 square kilometers in area and is located in the central portion of Brazil, and is located on the western side of the Middle portion of the SF Basin. The Basin traverses two states, Minas Gerais and Goiás, as well as the Federal District. The Basin encompasses 10 municipalities, 6 of which are in Minas Gerais, 4 of which are in Goiás. The Preto River, the basin’s principal river, is a main tributary of the Paracatu River, one of the headwater tributaries to the São Francisco River (for more information on the São Francisco River Basin, please see Appendix 2-A).

There are two main seasons in the basin: the dry season (May-September) and the rainy season (October-April). Monthly precipitation varies from 0 to 90 millimeters in the dry season, and from 110 to 290 millimeters in the wet season. Throughout the year, temperatures vary from 20 to 28 degrees Celsius, with the hottest months occurring from September through March. Vegetation in the basin is mainly low-density cerrados, or savannah-like vegetation.
Figure 2-1. The Rio Preto Basin within the São Francisco River Basin. The SF Basin is shown in red in the context of Brazil. The Preto River Basin is then shown as a smaller basin in red, and then blown up.

The total population in the Basin is approximately 174,347, with 138,696 urban inhabitants and 35,651 rural inhabitants. Rural inhabitants, who are the focus of this study, live in farming communities, large farms, or Agro Vilas (small communities which are more urbanized than farming communities). For this study, the rural inhabitants of interest are those residents practicing subsistence or irrigated agriculture, and living in small farming communities with less than 400 people.

The basin contains urban, semi-urban and rural areas. In the rural areas, land use is dominated by two main types of land-use: industrial agriculture (Figure 2-2), small-scale agriculture (Figure 2-3) and subsistence agriculture. Typically, farmers in small farming communities practice a mixture of market-oriented agriculture (vegetable or milk production) and subsistence agriculture. These farmers tend to have parcels of land less than 45 hectares in area, but averaging 5 hectares. Industrial agriculture farms are typically owned by one owner or family. These farms, averaging 100 to 500 hectares specialize in the industrial-scale production of rice, beans, soybean, corn and dairy.

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Traditionally, these farms were rain fed, but increasingly, large farmers are installing center-pivot irrigation, drawing water from groundwater or nearby streams. Most recently, large farms are building private small reservoirs to meet their irrigation needs.

**Figure 2-2.** Center pivot irrigation on an industrial farm.

**Figure 2-3.** Small-scale irrigation of vegetables on a small farmers’ land.
A number of water conflicts are present in the Preto River Basin. A study conducted by Brasilia’s Catholic University (2003), registered a number of water conflicts. The study cited three common types of conflicts: 1) conflicts between small-scale farmers, 2) conflicts between small and large-scale farmers, and 3) conflicts between large-scale farmers. The study notes that conflicts of the first type are due to a lack of collective maintenance and organization around communal canals. Conflicts of the second type are due to the fact that large-scale farmers place center pivots at the headwaters of streams, diverting too much water from downstream communities. Conflicts of the third type are caused by large farmers irrigating at the peak of the dry season. Finally, the study considered the possibility of a fourth type of conflict: one between farmers and hydro-power producers, mainly because the energy producers change flows of the Preto River.

Land tenure in the Basin’s rural areas can be broken into four main categories: 1) Fee simple absolute ownership, 2) renters, 3) long-term leases, and 4) non-sanctioned, or “illegal” settlements, not officially sanctioned by the government. In general, large industrial farms are owned by the farmers. In general, small farming communities have long-term leases on the land, or are sometimes fee-simple owners.

A significant number of rural communities in the basin are assentamentos, or government-financed resettlement communities for once landless peoples, where the main type of land tenure regime is a long-term lease. In most cases, families in resettlement communities have received government contracts to lease the land without a fee for 5 to 50 years. Most families cited the high possibility of renewing these contracts. In addition, families can buy the contract from another family in the community. And, several families can live in one parcel at a time. The contract allows the title to be passed on to children, or other family members.

Two main types of assentamento communities exist in the basin: those which were established by the government in the late 1970s, and those which have been more recently established. In

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Federal District’s PAD/DF region, for example, the government redistributed land and formed “resettlement” communities in the late 1970s. In the municipality of Unai, in the state of Minas Gerais, resettlement communities are less than 15 years old. This fact creates a clear distinction, with some more established than others.

**General Description and History of the Regions Studied**

This study focused on communities in the PAD/DF-Jardim region, and areas of the municipality of Unai that are within the Preto River basin’s boundaries. The rural areas of the PAD/DF and Jardim areas are located on flat and extensive plateaus. Although the region was once dominated by cerrados vegetation, much of this original land cover has been deforested, and converted to industrial agriculture. This agriculture, dominated by soybean, corn, rice and bean production is a critical part of the region’s economy, and plays an indirect role in the development of rural resettlement communities.

Until the early 1980s, the entire PAD/DF region was large-scale, single-owner farms. Due to heightened land conflicts (Rodrigues et al. 2004), the government implemented an agrarian reform policy, dividing some of the large farms into 5-10 ha lots which were then distributed to landless peasants, many of whom were working on the large farms at the time, as well as others who migrated from the southern and northeastern regions of Brazil. This program, named the Programa de Assentamentos Dirigidos (PAD), or the Program for Directed Resettlement, gave the region its name, the PAD/DF, with the DF referring to the Federal District.

Today, the PAD/DF region is composed of small farming communities that were originally resettlement communities, AgroVilas which are a hybrid between small urbanized communities located next to farming communities, landless people settlements, urbanized communities along the main roads, and large industrial farms that span 100-500 hectares, on average.

In the state of Minas Gerais, Unai is one of the most important agricultural municipalities. Located in a region of valleys (Figure 2-4), Unai’s main agricultural practices are the production of coffee, grains and milk. Clustered across the municipality are twenty three resettlement communities,
of which roughly 18 are within the Preto River Basin’s boundaries. While similar to resettlement in the PAD/DF region in terms of their initial set up, these communities differ in that they were established in recent years (mid to late 1990s, as opposed to late 1970s and early 1980s).

Figure 2-4. Valleys in Unaí.

General Characteristics of the Communities Studied

This study focuses on seven rural farming communities within the PAD/DF and Unaí regions. Four communities6 in this study are located in the Federal District’s PAD/DF and Jardim region: Buriti Vermelho, Capão Seco, Lamarão and Nucleo Rural Jardim. Despite differences, these communities are similar in several ways. First, all are characterized by having a mixture of land-uses and livelihood strategies, consisting mainly of subsistence agriculture and small-scale vegetable production. Second, all four communities have some type of government financed small-scale irrigation infrastructure, be it small reservoirs or weirs that divert water from a stream to a canal. Third, all four communities were established as resettlement communities in the late 1970s. Fourth,

6 For the purposes of this study, a community is defined as a distinctly bounded group of parcels with one to several households living in each parcel. Each community is distinguished by its unique name, which is recognized by state and local institutions.
all four communities have EMATER agents working with them. Finally, all four communities are surrounded by large-scale industrial farms.

The additional three communities in this study are newer resettlement communities located in the municipality of Unaí, in the state of Minas Gerais. These communities are Campo Verde, Paraíso and São João Batista. Despite differences, these communities also share a number of common characteristics. First, all depend largely on subsistence agriculture as well as milk production for economic livelihoods. And none of these communities have small reservoirs, or similar-style small-scale infrastructure for irrigated agriculture. Tables 2-1 and 2-2 describe key historical events related to water and small reservoirs in the communities studied. For additional information on these communities, see Appendix 2-B.

**Table 2-1.** Key events regarding community development and water infrastructure establishment for communities in the PAD/DF-Jardim region.

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Buriti Vermelho</th>
<th>Capão Seco</th>
<th>Lamarão</th>
<th>Nucleo Rural Jardim</th>
</tr>
</thead>
<tbody>
<tr>
<td>1977-mid 1980s</td>
<td>- government redistributes land and establishes resettlement communities</td>
<td></td>
<td></td>
<td>- government builds and finances small reservoir and 3 canals</td>
</tr>
<tr>
<td>1980-1983</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1982</td>
<td></td>
<td></td>
<td>- government builds small reservoir and canal</td>
<td></td>
</tr>
<tr>
<td>1984/85</td>
<td>- weir and canal system built by government</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1997</td>
<td></td>
<td></td>
<td></td>
<td>- 12 community members finance lining of canal, and limit access to canal water</td>
</tr>
</tbody>
</table>
Table 2-2. Key events regarding community development and water infrastructure establishment for communities in Unaí.

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Campo Verde</th>
<th>Paraiso</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>- INCRA establishes community</td>
<td>- INCRA establishes community</td>
</tr>
</tbody>
</table>
| Early 1990s   | - INCRA provides pipes for drinking water, but does not install groundwater pump or tank  
- Community Association obtains rural credit to finance groundwater pump and communal water tank  
- Neighbor in community allows the community to install groundwater pump on his property, as long as they pay the bill | - Community association obtains funding from BID to improve water infrastructure in the community.                                                                                                     |
| 2003-Present  |                                                                                                                                                                                                              |                                                                                                                                                                                                         |

Small Reservoirs in the Preto River Basin

Initially, the establishment of small reservoir systems in the basin was driven largely by community needs, and government foresight, support and financing. For example, in the 1970s and early 1980s, the government in the PAD/DF region of the Preto Basin, established a number of resettlement communities. After the initial establishment of these resettlement communities, some families left because they could not make a living (Rodrigues et al 2004). To remedy this effort, the Federal District government financed the initial building of the small reservoirs and canal systems in some communities, hoping that irrigation would allow farmers to grow and sell vegetables, which could serve as a source of income generation. In the late 1980s and 1990s, as indicated, some communities, such as Buriti Vermelho and Nucleo Rural Jardim decided to make improvements to the system, with the support of EMATER.

Today, these reservoirs are best understood as part of an interlinked physical and social system. Narrowly speaking, small reservoirs in the Preto River Basin are earthen dams, constructed

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7 This study defines size by surface area and end-user attributes. This is in part because researchers in the Preto Basin tend to define small in terms of surface areas that range from one to forty-five hectares (personal communication). However, because this study is concerned with livelihood impacts of small reservoirs on poorer populations in rural settings, it adds a second component to the definition: the use of these reservoirs.
on a river or stream bed, so as to obstruct the natural stream flow and contain this water in type of retention basin (Figure 2-5 and 2-6). The actual storage volume of the reservoirs that I studied is used as a source of water for only a few days each year, when there is virtually no inflow to the system. Aside from this, a principal function of these reservoirs is to elevate the water level, allowing for gravity to feed water down the canal system. Small reservoirs in the region are not actively operated. This means that with the exception of the diameter of the pipe that diverts water from the canal to the canal system, there is no direct control of flow into, or out of the reservoir.

**Figure 2-5.** Side view schematic of a small reservoir. An earthen dam blocks stream flow. Behind this dam, water is stored in a reservoir, up to a certain height.

**Figure 2-6.** One of two small reservoirs in the community of Buriti Vermelho.
The reservoir’s surrounding catchment area drains additional water into each reservoir, by means of runoff and groundwater flow. While the earthen dam serves to retain and store water, a spillway on one of the sides of the reservoir allows excess water to spill-over when the capacity is exceeded (Figure 2-7). In some cases, the spillway may feed into a natural stream. In other cases, it may feed into another reservoir. Water from these reservoirs is transported downstream for on-farm use; in the Preto River Basin the main use of this water is currently for irrigated agriculture.

**Figure 2-7.** Spillway that allows excess water to drain from the reservoir if capacity is exceeded.

**Variations in Small Reservoirs**

Among rural farming communities of the Preto River Basin, small reservoirs exist in a variety of forms. In some cases, these reservoirs are cascade reservoirs, with one main reservoir located at the headwaters of a stream, and at least one more reservoir slightly downstream (Figure 2-8). This is the case in the community of Buriti Vermelho. In other cases, there are simply one or more small reservoirs in separate locations, as is the case in Nucleo Rural Jardim, where two different streams feed two different reservoirs.
Rural Livelihoods and Access to Resources in Relation to Small Reservoirs

**Figure 2-8.** Schematic of a cascade of small reservoirs. Here, an upstream small reservoir is located just above a second small reservoir, and water from one spills over into the next.

In some rural communities, there is no small reservoir in the sense of an earthen dam blocking the stream flow, but there are weirs. This is the case in the community of Capão Seco. Here, a weir placed on the stream diverts water from the stream directly to a canal system that functions just like the previously described canal systems. Because there is no control at the dam wall (of the reservoirs), the reservoirs function in approximately the same way that weirs do. Thus, the weir structure in Capão Seco is included in the analysis of communities “with small reservoirs”.

*From Infrastructure to System*

In the Preto River Basin, it is not enough to discuss the earthen dam portion of the small reservoir infrastructure. Instead, it is important to understand that small reservoirs are a central part of a larger physical irrigation system, composed of canals, pipes and on-farm storage units (Figure 2-9).

Each community with a small reservoir has at least one canal that transports water downstream to farmers in a given community. In the communities of Capão Seco and Lamarão, for example, one canal diverts water from the small reservoir to individual farms. In Buriti Vermelho, two main canals divert water from two different cascading reservoirs, and one of these two canals splits into a third canal.

Depending on whether a community has obtained additional credit or financing to line the canals with concrete, these canals may be earthen and uncovered, or concrete and closed. In Capão Seco and Lamarão, for example, the canal system is open and earthen (Figure 2-10). In Nucleo Rural Jardim and Buriti Vermelho, the canal is a closed, concrete-lined canal (Figure 2-11).
Figure 2-9. Photo of on-farm storage pond. Farmers line ponds with plastic and store water that is diverted from the canal on their individual properties.

Figure 2-10. Earthen, open canal in the community of Lamarão.
While canal flow is not formally regulated at the top of the system (i.e. at the site of the reservoir), in a majority of cases, some form of “regulation” can occur individually at the site of divergence from the canal to the on-farm storage unit. Specifically, at “check-boxes” along the canal individual farmers control the flow of water that is diverted from the canal to their farm by opening and closing a connecting pipe.

On the farm, water is stored in small, lined storage ponds (Figure 2-13). That water is stored on-site by individual farmers is a crucial point to consider from a water management perspective. This indicates that one can conceive of two types of “small reservoirs”, ones that serve the entire system, and ones that serve individual farms. Furthermore, this could indicate that flows in the canal itself are not enough to meet water supply, and therefore on-site storage serves as a buffer for water demand. In essence, these storage units function as a form of additional security in terms of water storage. However, as discussed below, the management of who fills his/her storage unit, as well as when and how often are critical questions to consider in terms of the management of small reservoirs. Figure 2-12 shows a schematic of this bigger system.
**Figure 2-12.** Schematic representation of the physical irrigation system of which small reservoirs are a part. This schematic is best understood from bottom to top. The small reservoir is usually placed along a stream. Water enters the small reservoir, via an upstream inlet (i.e. a stream or spring). A canal transports water to individual farms. At check boxes along the canal, individual farmers divert water from the canal via a pipe. This water is stored on-site in a retention/storage pond. Excess water in the small reservoir flows out via a spillway (right) and usually enters a stream.

*Small Reservoirs as a Social System*

While it is easy to consider the physical small reservoir system as static and composed of a network of permanent physical components, in fact, these systems have been built and are controlled by a dynamic social system in each community. This system is composed of a series of interacting institutions and organizations. To varying degrees, this social system defines current day management and water use regimes, and has shaped the physical systems of small reservoirs over time.

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8 Here, the term institution, in North’s (1999) language refers to the “rules of the game”, what could otherwise be termed the practices, norms and regulations. The word organization refers to the players involved (North 1990).
The farming community of Buriti Vermelho is an example of how social systems within a community are involved in the development and use of small reservoirs. In the late 1970s, the government helped build reservoirs and the accompanying earthen canals in Buriti Vermelho. In the mid 1990s, the community decided to line these canals with concrete, and add one more canal to the system. With the help of EMATER, the Brazilian agricultural extension agency, Buriti Vermelho's community association received funding from the government to do so. However, the government required cost-sharing by the community. At this point, the community decided that only those farmers who helped contribute funds or labor would have access to the irrigation system.

The situation is similar in Nucleo Rural Jardim. One of the two small reservoirs in the community was built in the early 1980s by the government, along with three canals. The canals were left open until 1997. In 1997, local community members banded together to finance the lining of the canals. However, only 12 community members were willing to make the investment of 40,000 Reais (or approximately $19,448 in 2006 dollars). These farmers decided that only those who helped pay for the canal would be able to use the canal water, and this agreement still holds. In essence, the twelve farmers who use the canal water function as a Water Users Association, meeting and discussing water management issues, if necessary.

In Lamarão and Capão Seco, a looser social system governs how small reservoirs (or weirs) have developed over time. In Lamarão, for example, since the reservoir's establishment the canals have not been lined with concrete. Instead, a loose, to non-existent management system is in place, where only some farmers use the reservoir water. In Capão Seco, only four farmers use water from the canal for irrigation. Here, only those that were interested in installing drip irrigation, with the help of EMATER, use the water for this purpose. No specific management system seems to be in place.

These examples serve to define the boundaries of the social system, and its roles. While the degree of involvement of the social system varies, in all four cases, the system associated with small reseroirs...
reservoirs is usually dominated by the local community association, outside government support, technical support from EMATER, and the farmers. Table 2-3 describes the generic parts of the physical-social system, and Figure 2-13 represents a model exemplifying how this social system has worked in communities like Buriti Vermelho and Nucleo Rural Jardim.

Table 2-3. Description of parts, players and functions of the physical and social systems of small reservoirs.

<table>
<thead>
<tr>
<th>Physical System</th>
<th>Social System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parts and Players</td>
<td></td>
</tr>
<tr>
<td>Small reservoir</td>
<td>Federal government</td>
</tr>
<tr>
<td>Canal(s)</td>
<td>Municipal government-PAD/DF</td>
</tr>
<tr>
<td>Spillway(s)</td>
<td>EMATER-PAD/DF</td>
</tr>
<tr>
<td>Check-boxes</td>
<td>Community association</td>
</tr>
<tr>
<td>On-farm storage unit</td>
<td>Water users association</td>
</tr>
<tr>
<td></td>
<td>Farmers</td>
</tr>
<tr>
<td>Functions</td>
<td></td>
</tr>
<tr>
<td>Store water</td>
<td>Operation</td>
</tr>
<tr>
<td>Control flow</td>
<td>Maintenance:</td>
</tr>
<tr>
<td>Purvey water</td>
<td>Regulation</td>
</tr>
<tr>
<td></td>
<td>-cleaning</td>
</tr>
<tr>
<td></td>
<td>-financing and credit</td>
</tr>
<tr>
<td></td>
<td>-uphold norms</td>
</tr>
<tr>
<td></td>
<td>Shape System Over Time</td>
</tr>
</tbody>
</table>

Figure 2-13. A schematic of the social system related to small reservoirs. This social system is composed of players (in blue circles) and institutions (dotted circles), that together have yielded specific results in individual communities (square boxes). As a whole, the system is evolving over time, with time moving towards the right. The below model could represent the community of Buriti Vermelho.
Overall, one can conceive of the social system tied to small reservoirs as performing three main functions: 1) To uphold community norms and regulations regarding community-level access to water from the physical system, 2) To ensure the maintenance and upkeep of the system, and 3) To enable the maintenance of the physical system, both through physical and financial inputs.

In terms of the first function, the broader social system provides the framework for institutions and players to define and maintain community decisions regarding access to the water supply system. This can be observed in three important aspects. First, in all three communities with small reservoirs the community association (a player) is, in theory, available to mediate water disputes among water users. Here, the mediation is part of the institutional process. Second, in Buriti Vermelho and Nucleo Rural Jardim, the community association and water user association (in Nucleo Rural Jardim) ensure that only farmers who helped pay for improvements to the canal system can use the water provided for by the system. In this case, the relevant institution is the set of rules that has been established and is upheld by the key players (i.e. the associations). Lastly, tacit water use rules can exist, as evidenced in Buriti Vermelho. Here, farmers fill their on-farm storage units at any given time, and only change their practice if there is a drought or if a change is mandated by the community association. In this case the farmers are the players, and they are abiding by a tacit set of institutional agreements regarding when to access their given demand for water.

In terms of the second function, the players in the social system enable the maintenance of the physical system. This takes place in one of two ways. On a day-to-day basis, the community associations in Lamarão and Buriti Vermelho, or the Water Users Association in Nucleo Rural Jardim, decide when canals should be cleaned. Depending on what the associations decide, farmers respond accordingly. On a longer-term scale, a series of players within the system (e.g. the community association and other institutions) can seek rural credit or outside financing to upkeep the physical system. Finally, as observed in Buriti Vermelho and Nucleo Rural Jardim, over time, a broader function of the social system has been to shape the physical system, helping to establish, improve and maintain the small reservoir system.
In sum, the social system that revolves around small reservoirs has functioned across time and space, and at multiple scales. This system, though open to critiques\textsuperscript{10} lies at the backbone of community-level management of small reservoirs. By holding a holistic vision of small reservoirs one begins to understand the complexity of resources (tangible and intangible, physical and institutional) needed for small reservoirs to provide livelihood benefits. If researchers, policy makers and communities are to consider building more small reservoirs, they should not lose sight of the current need to support the proper institutional support mechanisms that the intertwined physical and social systems require. These points are important to keep in mind when considering the topic of the next chapters, the role of small reservoirs in rural livelihoods and the resources necessary to receive benefits.

\textsuperscript{10} It is important to note that this system-level description does not evaluate the performance of the system, or of its parts, it only provides a snapshot in time of the current-day characterization of the system.
CHAPTER 3: Results on the Role of Small Reservoirs in Rural Livelihoods and Issues of Access

Introduction
One of the questions this study seeks to ask is: to what extent do small reservoirs currently contribute to the livelihoods\textsuperscript{11} of rural communities? To answer this question, this chapter applies the Sustainable Rural Livelihoods (SRL) approach, as outlined by Scoones (1999). In applying this broad approach, which defines livelihood strategies and related outcomes, this chapter highlights the various benefits that small farmers derive from small reservoirs. In addition, as noted in the introduction, the results show that it is not enough to consider the impacts of a given livelihood strategy\textsuperscript{12}. In fact, in following Scoones’ (1999) recommendations of: 1) Defining the resources on which these strategies (and outcomes) depend, and 2) Identifying the institutional processes that support these livelihood strategies from occurring, a second question emerges. This question is: What factors determine whether individuals or communities receive, or could receive these livelihood benefits? In answering both aforementioned questions, this chapter shows that while small reservoirs provide economic and non-economic impacts, adequate access to economic, institutional and social resources, as well as to water is necessary to receive livelihood benefits.

Livelihoods in the Preto River Basin
Rural livelihood strategies in the Preto Basin’s farming communities with small reservoirs are dominated by four main livelihood activities: production of irrigated crops, off-farm income generation, dairy production and subsistence farming. With the exception of subsistence agriculture, these livelihood strategies can be conceived as main sources of income, as shown in Figure 3-1.

\textsuperscript{11} As defined by Miriam-Webster, a livelihood is the “means of support or subsistence” of a specified unit (Website Miriam-Webster). The University of Sussex’s Institute for Development Studies (IDS) expands upon this definition, noting that a livelihood “comprises the capabilities, assets (including both material and social resources) and activities required for a means of living” (Scoones 1998).

\textsuperscript{12} A livelihood strategy is the cluster of methods that an individual, group or region employs to support itself or to subsist (Scoones 1998).
In the communities of Buriti Vermelho, Nucleo Rural Jardim, Capão Seco and Lamarão six of the nine households (67%) interviewed produce fruits or vegetables that are sold. Specifically, 3 of the 6 households are in Buriti Vermelho, 1 of the 6 is in Lamarão and 2 are in Nucleo Rural Jardim (Figure 3-2). For these farmers, irrigation allows for the production of these crops. To irrigate these crops, farmers also rely on a range of irrigation technology, ranging from furrows and sprinklers to drip irrigation. Farmers then sell their crops at farmer's markets that supply the vegetables to regional markets. While Figures 3-1 and 3-2 show that only five of the nine respondents practice this livelihood strategy as a primary source of income, one household in Buriti Vermelho that indicated that off-farm income is the primary source of income noted that irrigated agriculture is a secondary source of income, totaling to 6 irrigating households.

Another way to observe this livelihood strategy is to revisit Figure 3-1. Of the 9 respondents living in one of the four “small reservoir communities”, five (55%) report sales in irrigated crops to be the primary source of income. Seven out of the nine households (78%) indicated that sales of
irrigated crops are the primary or secondary source of income. This underscores the general income benefit of irrigation.

**Figure 3-2.** Primary source of income by community for communities with small reservoirs.

A second livelihood strategy in these communities is to rely on income earned outside of the farm, either by current household members, or by household members that have migrated outside of the community. In Buriti Vermelho, for example, one of the three respondents whose family produces irrigated crops indicated that while her husband works as a farmer, she teaches at a local school, bringing home an additional source of income. In Capão Seco, the one household interviewed indicated that some household members who have migrated to the city send some type of income “back home”. Though this behavior is likely evident in other households, only one interviewed household reported this.

The third livelihood strategy is to produce milk or cheese, or sell livestock that are in possession of a particular household. In Nucleo Rural Jardim, for example, one of the three families makes cheese from their cows’ milk, and sells these blocks of cheese. This family indicated that this was a primary source of income.
While not captured in interview results, field observations indicated that a fourth type of livelihood strategy exists in these communities: subsistence agriculture. Subsistence farmers are present in almost all communities, regardless of whether there is a small reservoir. These farmers produce manioc, rice and beans for household consumption. In Nucleo Rural Jardim, for example, fourteen of the forty-six parcels have irrigated agriculture; the remaining parcels have some form of subsistence agriculture (which may be complemented with another income-earning practice, such as milk or cheese production). Several of the subsistence farmers indicated that if there is excess food they may store it for food security, or sell it for supplemental income\(^\text{13}\).

The aforementioned agricultural strategies can occur alone, or in tandem with one another, either at the community or household. In the case of the latter, Scoones (1999) considers this a livelihood diversification strategy. Table 3-1 categorizes each of the aforementioned livelihood strategies by Scoones’ generalized definitions of livelihood strategies. Table 3-2 indicates the types of livelihood strategies present in each community, as indicated in the interviews.

**Table 3-1. Classification of specific livelihood strategies by Scoones’ more general definitions (top row).**

<table>
<thead>
<tr>
<th>Scoones’ Category: Specific Livelihood Strategy</th>
<th>Agriculture</th>
<th>Migration</th>
<th>Intensification</th>
<th>Diversification or Agriculture+ Migration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subsistence Agriculture</td>
<td>Off-Farm Work, or Irrigated Crop Production</td>
<td>Cheese or Milk Production</td>
<td>Irrigated crop production and Off-farm Income,</td>
<td></td>
</tr>
<tr>
<td>Urban income is sent home</td>
<td>Subsistence Agriculture and Off-Farm Work</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(^{13}\) Scoones would define subsistence agriculture as “extensive agriculture” because it is labor-led (Scoones 1998), relying more on immediately available labor and social resources.
Table 3-2. Results indicating the presence or absence of specific livelihood strategies by community. The presence of an “X” indicates that at least one respondent follows this strategy. The absence of an “X” does not mean that the strategy does not exist in the community; it merely means the households interviewed did not indicate this strategy.

<table>
<thead>
<tr>
<th>Type of Income Source/Community</th>
<th>Agriculture</th>
<th>Migration</th>
<th>Intensification</th>
<th>Diversification or Agriculture+ Migration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Subsistence Agriculture</td>
<td>i) Off-Farm Work, or ii) Urban income is sent home</td>
<td>Irrigated Crop Production</td>
<td>Cheese or Milk Production</td>
</tr>
<tr>
<td>Buriti Vermelho</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Capão Seco</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Lamarão</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Nucleo Rural Jardim</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

Economic Benefits of Small Reservoirs

The main impact that small reservoirs currently have on rural livelihoods is income generation. Small reservoirs provide a year-round supply of water, allowing small farmers to irrigate their crops during both the wet and dry season. This supports a critical livelihood strategy—that of market-oriented crop production—and yields a tangible outcome, income generation. As discussed above, six of the nine households (67%) interviewed in communities with small reservoirs produce crops using irrigation. Five of these six (83%) farmers who have irrigation use water from a small reservoir to produce their vegetables. Specifically, 2 of the 3 households in Buriti Vermelho who practice irrigation use a small reservoir. One of the two farmers in Lamarão uses water from the small reservoir, and both respondents who use irrigation in Nucleo Rural Jardim use a small reservoir. These results indicate not only the important role of irrigation, but the significant role that small reservoirs play in this process.

Interviews with institutional representatives that work in communities with small reservoirs underscored the broad socioeconomic impacts of small reservoirs. For example, one of the two EMATER agents that works in communities with small reservoirs noted that “those who have
irrigation are at a better socioeconomic level...Day laborers and subsistence farmers have less of a
good life.” This response highlights the perceived benefit of having irrigation. This respondent
added that, in addition, for those farmers who use drip irrigation, they are able to produce even more
vegetables (and thus produce more income).

That irrigation and water supplies from small reservoirs have an important economic
outcome is further substantiated by the fact that even if people do not have access to canal water,
farmers use alternative water sources for irrigation. As discussed further below, in Nucleo Rural
Jardim, one respondent uses a private reservoir managed by his neighbor. In Buriti Veremlho, a
second round of field interviews indicated that while 57%14 of all households (17/30) in the
community use canal water, an additional 27% (8/30) of farmers irrigate using alternative water
supplies, such as springs or the Estreito stream. Together, these results suggest that households
receive a benefit from irrigation, and are therefore willing to seek out alternative sources of water for
irrigation, if needed.

In addition, to their income generation possibilities, small reservoirs can be used to decrease
domestic expenses, and provide water for domestic water uses. One such role is in decreasing energy
bills and providing an additional source of domestic water. For example, two of the nine households
interviewed noted that they might draw canal water to wash clothes, since they do not have to pay
for the energy bill of this water. In this sense, there are economic benefits that are less obvious than
income generation alone.

Finally, another indirect economic impact is related to reduction of climate vulnerability.
Interviews with both farmers who irrigate and with institutional representatives that work in
communities with small reservoirs indicated that small reservoirs serve as a buffer against droughts.
For example, some respondents noted that if there is a dry spell during the wet season, they can
irrigate their crops with water from small reservoirs. Similarly, the two EMATER representatives
noted that though there is adequate stream flow throughout most of the dry season, a few weeks of

14 Data obtained from complementary socioeconomic survey conducted by SRP field team in Brazil, (Jozeneida
and Tito).
each dry season require tapping the storage capacity of the small reservoirs for additional irrigation
supply. On a more basic level, farmers also noted that small reservoirs allow them to plant in the dry
season, when there is not enough rain. These results show that people recognize the climate-related
benefits. These benefits, indirectly allow for crop production, which yields income. And in the face
of future climate change these systems could buffer the water availability even more (which goes
beyond having positive economic impacts).

Non-Economic Benefits

In addition to the economic benefits received indirectly from small reservoirs, respondents
discussed a number of non-economic benefits that they receive. One role that small reservoirs can
play at the domestic level is to indirectly provide a nutritional supplement. While all six households
that produce vegetables noted that they sell all the crops produced, when probed further respondents
noted that they eat a small amount of their harvest every week. From this finding, one can surmise
that there is an important nutritional supplement to daily diets, which can be attributed in part to
small reservoirs. Chambers (1995) would likely argue that this is important livelihood benefit from
the perspective of well-being.

And, occasionally small reservoirs indirectly provide water for livestock. For example, one
respondent in Capão Seco noted that although she does not irrigate, her cattle drink from the canal.
This is a non-economic benefit in that families oftentimes consume these animals. It also could be
an economic benefit in that in some cases, these animals are sold for additional income, or help
produce milk or cheese, sources of additional income. This result, though small in terms of sample
size, also offers a potentially interesting contrast to small reservoirs in other parts of the world where
livestock might rely on small reservoirs as a primary and direct source of water.

Resources Necessary for Livelihood Strategies

Given the above results, one can begin to understand the important role of small reservoirs
in livelihoods. But, what is required to achieve these livelihood results? To answer this question, it is
important to look at the resources that are necessary for such a livelihood strategy. Despite the
significant livelihood outcomes that farmers discuss, the theory on livelihoods, as well as interview results indicate that access to diverse types of resource are required for this livelihood strategy.

Scoones (1999) outlines five main types of resources that are used when employing any given livelihood strategy. These resources include natural capital (soil, water, etc), human capital (skills, education, etc), economic/financial capital (assets, credit, income) and social capital (access to institutions and networks). As an abstract example, subsistence agriculture farmers in these communities depend on soil, water and ecology of the region (natural capital), livestock for household consumption or occasional sale (economic/financial capital), their agricultural skills and knowledge (human capital), and the support of their community association and rural agricultural extension agencies, such as EMATER (social capital).

Using these five categories, interview results and field observations indicate that households that have irrigated crop production rely particularly heavily on economic and financial capital, as well as on social capital. For example, from an economic/financial capital perspective, these households depend on the physical infrastructure of small reservoir systems, credit to upgrade these systems, and agricultural inputs (e.g. fertilizers and machinery) to maintain the agricultural system. In terms of human capital, these farmers depend on additional skill sets, such as how to irrigate and operate necessary machinery and additional labor requirements necessary for more intensive agriculture. In terms of social capital, these farmers rely on the organizations outlined in the previous section—government agencies, EMATER, community associations, water users associations, markets and institutions—to gain access to human and economic resources. Together, these facts highlight the unique attributes of resources necessary for such a strategy. This is useful when considering the potential barriers that may exist to following small reservoir-dependent livelihood strategies.

Beyond these five resources, however, field results also indicate that a series of institutional processes are necessary for supporting the production of irrigated crops, a result that once again supports Scoones’ (1999) emphasis on the institutions involved in livelihoods. These processes include the network of processes that allow for marketing vegetables, the social organizations that
support farmers in accessing economic and human resources that are necessary for production, the technical support provided by outside organizations, and the labor inputs that farmers use.

For one, farmers who use irrigation and sell vegetables in local rely on access to a series of market-oriented processes. These processes include the selling of the vegetables and the infrastructure necessary to transport the crops to market. Farmers either take their produce to market in a community truck, or they sell their produce to a middleman who buys the produce on-site, and sells it at the farmer’s market. In Buriti Vermelho, for example, some farmers organize to transport their goods together. In Lamarão a community-owned truck is available for farmers to transport their goods. In Capão Seco, one farmer interviewed in an informal interview noted that an outside middleman comes to the community to pick up vegetables from him. These results not only indicate that farmers are reaping economic livelihood benefits because there exist road systems, transportation and farmer’s markets where their products can be sold, they also indicate that social organization help farmers access and utilize economic resources necessary for agricultural production.

Beyond market-oriented support mechanisms, farmers who irrigate also discussed their reliance on outside technical support. Farmers continually expressed how EMATER helped them install efficient irrigation systems, or how EMATER helped obtain funding for irrigation technologies. These results corroborate the general knowledge that in the PAD/DF, EMATER is highly involved in irrigation support, and has helped farmers make the transition from subsistence to irrigated agriculture, as well as from furrow and sprinkler systems to drip irrigation. Both institutional surveys and community surveys confirmed this fact.

Though not discussed as readily, respondents also hinted at the role of labor in the irrigated crop livelihood strategy. Some households interviewed indicated that the only source of labor was from within the household. However, at least two of the nine farmers who irrigate noted that they hire labor, either from the community or from outside the community. In this sense small reservoirs also provide labor and employment for community members.
Finally, as discussed in Chapter 3’s social system description, interviews in communities with small reservoirs indicated the important role of historical institutional support. For example, when asked to describe the role of the government in the building and maintenance of small reservoirs, respondents indicated that historically, different government agencies, particularly the Zoobotanical Foundation (a branch of the government) helped build the original small reservoir infrastructure. Respondents also noted that later, with the help of EMATER, communities solicited additional credit, especially from the municipal governments, to make changes in the irrigation system (i.e. lining of canal systems). In this sense, by having access to government support, rural credit and the support of EMATER, these communities have been able to finance upgrades for small reservoirs.

Reliance on these resources underscores the point that a small reservoir in a community will not in and of itself ensure livelihood benefits. Rather, the physical and social system alongside necessary financial, institutional, economic and water resources are all necessary to yield livelihood benefits.

Access to Water

It is very important to consider questions of access to the water resource supplied by the small reservoirs. Here, interviews with farmers indicate that access to the water provided by small reservoir systems is unequal15.

Interviews with farmers and EMATER representatives highlighted that there is unequal access to small reservoirs due, in part, to norms and regulations associated with small reservoirs. As mentioned previously, certain historical decisions limit access to reservoir-supplied water, and therefore the livelihood benefits derived from this water source. For example, as already discussed, when farmers in Nucleo Rural Jardim and Buriti Vermelho decided to upgrade their small reservoir systems (lining canals with concrete, adding more canals, etc) community members decided that only those households who contributed to the lining of the canals, either with labor or money, were allowed to use the canal.

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15 Here, unequal means that the allocation of the water supply is not equally distributed in the sense that some farmers have all their water needs met, and others do not. Unequal does not imply inequitable, which would imply one step further—a judgment that the distribution is not fair.
This “historical right” still persists today, and is a major determinant of access. In Buriti Vermelho, thirteen of the thirty parcels do not use canal water (43%). Of these thirteen, five only have rain fed agriculture, and eight irrigate with water from other sources (streams and springs). The remaining 17 parcels (57%) use irrigation water that comes from the small reservoirs. In Nucleo Rural Jardim, one of the three respondents noted that he is one of twelve farmers who have access to the water from the small reservoir because he helped upgrade the canal. Here, he made an important distinction: it is not that other farmers do not have access to the small reservoir itself, it is that the farmers do not have access to the canals that transport the water.

A second irrigator in Nucleo Rural Jardim further illustrates the point. Here, one household irrigates, but with water from a private small reservoir. The respondent noted that because his family did not have access to the community-owned small reservoir, they use their neighbor’s private reservoir. Apparently this household did not contribute money or labor, and is therefore excluded from using the “community-owned” small reservoir.

Beyond this inequality due to social norms, interview results revealed a less obvious type of inequality. In particular, even among those who have “historical rights” to the canal water, water supply and associated livelihood benefits are not necessarily shared equally. For example, one of the furthest downstream farmers in Buriti Vermelho noted that by the time the canal reaches his property, there is no water left in the canal, so as to fill his storage pond (Figure 3-3). As this farmer noted, “Everyone has [retention ponds], but...[The water] doesn’t come. I already complained, but nothing [happened]…the people above use the water...” Thus he attributes the lack of canal water to upstream farmers who have exhausted the water supply. When asked whether anyone receives priority in water use from the small reservoirs, he noted that upstream farmers use the water first. In this interview he went on to note that he believes upstream farmers block the canal to allow greater quantities of water to enter into their off-site storage units. In sum, the fact that remains is that not

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16 Data taken from second round of interviews conducted for the entire community. These interviews were conducted by other members of the research team.
everyone obtains water from the small reservoirs. Interestingly, this farmer still irrigates because he has a private spring on his property that supplies him with both domestic and irrigation water.

**Figure 3-3.** Photo of empty storage pond. By the time the canal that transports water from the small reservoir reaches this farmer’s parcel, there is no water left in the canal to fill the pond.

A similar type of response was provided by the second-to-last downstream farmer in Lamarão. This farmer noted that initially everyone tried to use the canal water. As opposed to Buriti Vermelho and Nucleo Rural Jardim, in Lamarão there is no historical limitation on who can access the reservoir water. Today, roughly twelve out of the eighteen farmers in Lamarão use irrigation for the production of vegetables. However, as the farmer who does not use the canal water noted, over time farmers found that there was not enough water for everyone. Therefore, some people, including him, stopped using the reservoir water. While this respondent was not able to elucidate reasons for who does use canal water today, the response indicates that such a question is worth asking.

The responses from these two farmers who both have theoretical rights to the water, but do not actually receive the water from the small reservoirs is important to explore. From a livelihoods perspective, it is important to consider the result of their lack of access to water. The farmer in Buriti Vermelho has decided to have irrigated crops, using water from his own spring. However, the
one in Lamarão does not have irrigated vegetables, and only produces some milk as a source of income. For both, it is worth asking, what is the cost of this lack of access to their livelihoods? The farmer in Buriti Vermelho partially addressed this question. In his case, he noted that while this inequality is not really a problem because he has a private spring, he did note that “if [he] could use the [canal] water, [he] would not have to spend as much money on pipes [and infrastructure]” for his private spring. The farmer in Lamarão did not address the direct impacts on his livelihood, but he noted indirectly that he would like to learn how to have organic agriculture. In some sense, this suggests that were he to have access to water from the canal, he may be interested in farming irrigated vegetables. This situation also spurs the questions: Is it merely downstream location that determines access? Or, are there also deliberate violations of water management schemes, power dynamics that drive who ultimately has access to the water, or simply poor water management mechanisms at play?

Conclusion:

In sum, this chapter highlights the important role that small reservoirs can play in supporting livelihood strategies. Currently, the main role these reservoir systems play is in providing a year-round supply of water to meet demands for vegetable production. Where small reservoirs currently exist, a series of benefits are associated with this specific livelihood strategy, ranging from economic and health benefits, to domestic and security benefits. Small reservoirs are both a resource supporting a key livelihood strategy, and a source of livelihood sustainability.

However, data from field interviews also indicate that communities with small reservoirs require a set of resources and institutional mechanisms to support livelihood outcomes related to small reservoirs. Rural credit and construction of the reservoirs are the basic building blocks of the system. And government financing, of both the structures and credit, has been essential. These points are critical to understand when thinking of how small reservoirs can fit into rural livelihood

17 For a discussion of other problems relating to small reservoirs, please see Appendix 4-A.
strategies. Furthermore, even as currently utilized, small reservoirs can support other aspects of livelihoods, such as domestic and livestock needs. These findings though less visible than the impacts of irrigated agriculture are important to consider, especially in light of the next chapter—one that focuses on whether small reservoirs could play a role in communities that do not currently have small reservoirs.

Finally, interview results also indicate that access to the water supply as distributed via the socio-physical small reservoir system also determines whether farmers receive livelihood benefits from these systems. These results indicate that we must expand our initial question beyond livelihood impacts to include questions of access to resources and water.
CHAPTER 4: Results on the Potential Role for Small Reservoirs in Rural Livelihoods

Introduction

The previous chapter emphasized the general livelihood strategies that exist in some communities with small reservoirs, and the benefits that result from strategies that rely on small reservoirs. The chapter concluded that in addition to considering the role of small reservoirs, we must consider the resources necessary to access the livelihood benefits. This chapter asks: 1) What role could small reservoirs play in communities without small reservoirs, and 2) How does access to economic, institutional resources and water affect these communities and their potential to benefit from small reservoirs? To answer these questions, this chapter looks at the present day livelihood strategies and water use characteristics within communities without small reservoirs, compares the challenges faced by these communities to communities without small reservoirs, and applies the findings from communities with small reservoirs to the analysis.

Livelihood Strategies

As in communities with small reservoirs, a range of livelihood strategies exist in communities without small reservoirs. Figure 4-1 shows that the primary source of income generation in Paraíso and São João Batista\(^{18}\) is milk production. Specifically, 4 of the 6 (67%) respondents in these communities cited this as the primary source of income. In Paraíso, two of the three respondent’s primary source of income is milk. Here, a select group of farmers have a dairy cooperative in which they share milk tanks, and sell over 45,000 liters of milk per month, or roughly 818 liters per parcel (assuming 55/78 households are involved, which is a conservative estimate). In São João Batista, the one respondent interviewed noted that milk is the primary source of income. Data from focus groups and informal interviews in Campo Verde indicated the importance of milk production. Here, respondents in Campo Verde indicated that the community sells a total of 9,000 liters per month, or roughly 215 liters per parcel (assuming all 42 parcels produce milk, which again is a conservative estimate).

\(^{18}\) Campo Verde is not included because data was collected via focus groups, not interviews.
The remaining two respondents, both from Paraíso, noted that day laboring and the sale of rain fed grains are their primary source of income. Here, one of the two respondents noted that her household does not have the money to invest in milk production, and therefore her husband works as a day laborer. The other household is primarily subsistence-focused and only sells rain-fed grains when there is an excess.

As with households in small reservoir communities, households in the Unaí communities exhibit diversified livelihood strategies. As Figure 4-1 also indicates, four out of six respondents have secondary and tertiary sources of income. Here, these sources include the sale of livestock (1/6 respondents), grains (2/6 respondents) and charcoal (1/6 respondents). These responses highlight the point that in addition to milk production, most respondents also practice rain fed agriculture. This agriculture not only results in producing rice, beans and manioc, staple food products which are consumed at home, the strategy also allow for a supplemental source of income when there is excess production (See Table 4-1).

**Figure 4-1.** Primary, secondary and tertiary income sources for the communities of Paraíso and São João Batista, in the municipality of Unaí.

![Income Sources for Paraíso and São João Batista](image)
Table 4-1. Income sources by respondent show the transition from primary to secondary and tertiary sources. The main trend to observe is the shift from milk production to rain fed and extraction-oriented sources of income.

<table>
<thead>
<tr>
<th>Respondent</th>
<th>Primary Source of Income</th>
<th>Secondary Source of Income</th>
<th>Third Source of Income</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paraíso</td>
<td>Milk</td>
<td>Livestock</td>
<td>Grains</td>
</tr>
<tr>
<td>1</td>
<td>Milk</td>
<td>Grains</td>
<td>Beans</td>
</tr>
<tr>
<td>2</td>
<td>Day laborer</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>3</td>
<td>Crops</td>
<td>Charcoal</td>
<td>Manioc flour</td>
</tr>
<tr>
<td>4</td>
<td>Milk</td>
<td>Grains</td>
<td>Chickens</td>
</tr>
<tr>
<td>São João Batista</td>
<td>Milk</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

In relation to small reservoirs, however, the critical point is that there is no livelihood strategy that relies on irrigation. In comparison with their counterparts in the PAD/DF region, only one in six of the Unai respondents have irrigation (Figure 4-2), and even here this one respondent noted that it is not a primary source of income. This respondent, from the community of Paraíso, has irrigation because his property is adjacent to the river.

Figure 4-2. Number of households who have irrigated parcels in communities studied.
The fact that in terms of economic livelihoods, water is not used as readily for irrigation\textsuperscript{19}, and that small reservoirs are normally used for irrigation in other areas of the Basin suggests that if small reservoirs are to be built in the future in these communities, perhaps they could complement existing water uses and livelihood strategies. Beyond a focus on economic livelihoods, however, additional interview results suggest that one could re-conceptualize the role of small reservoirs to move beyond supporting economic strategies to supporting other water need as well. Here, results related to basic drinking water needs offer compelling evidence.

\textit{Access to Drinking Water and Potential Roles for Small Reservoirs}

On a surface level, the drinking water characteristics of communities without small reservoirs do not seem to differ from communities with small reservoirs. In the PAD/DF-Jardim region, households in communities with small reservoirs receive water from one of two sources: groundwater that is pumped and stored in a communal water tank (Figure 4-3), or water from springs. In three of the four communities with small reservoirs, a water provider (i.e. CAESB) supplies domestic drinking water to all houses in a community for a cost. Six of the nine respondents (67\%) in the PAD/DF-Jardim communities use the groundwater pumped to the communal water tower as the primary source of water (Figure 4-4).

The remaining three respondents’ main source of water is spring water. One respondent in Buriti Vermelho is connected to the “water grid” but chooses to use the spring water because it is cheaper. One respondent in Capão Seco uses the spring because there is no other supplier of water in the community. Finally, one respondent in Lamarão noted that he prefers to use the spring on his property because he does not have to pay, and because the groundwater has been contaminated in the past.

When respondents were asked if they have problems with this water source, or if anyone receives greater priority, a common response was that there were no major problems with these

\textsuperscript{19} Except for home gardens, of which 3/6 have home gardens.
sources, but that depending on a household’s location a household might receive less water due to water pressure. Of all nine respondents, only one hints at a critical compelling drinking water problem—poor water quality in the community of Lamarão.

**Figure 4-3.** Water tower and tank in the community of Buriti Vermelho. CAESB, the water provider maintains the tower, paying a local community member for daily upkeep and management.

**Figure 4-4.** Main sources of drinking water by community.
Returning to communities without small reservoirs, drinking water sources and provisions are quite different. Here, three salient features of communities without small reservoirs emerge. The first is that, as compared to those households interviewed in the PAD/DF-Jardim region, a greater number of households obtain their water from sources other than a communal water tank. In some communities the spatial layout greatly affects the source of water for households. In Paraíso, for example, thirty-three of the seventy-eight parcels, or 42% percent of all parcels in the community border the Rio Preto River. Seven parcels, or 9% of all parcels, border a smaller stream. Twenty-three (29%) parcels are located in the upper cerrados portion of the community, and fifteen parcels (19%) are located between two nature reserves, at the foot of hillsides.

In general, farmers by the river obtain drinking water through two mechanisms; either they obtain water from hand-drawn wells, or they pump groundwater with electricity. In general, farmers in the upper area rely on the two existing groundwater pumps that store water in communal water tanks, similar to the one shown in Figure 4-3, but not managed by a private company. Water from this tank is then pumped to individual homes for drinking and domestic. This system does not extend to those farms located close to the river. Of the three respondents interviewed from this area, two rely on water from a communal water tank in Paraíso and one relies on water from a neighboring community. Of the three respondents interviewed who live by the river, all three rely on wells as their primary source.

In São João Batista, the one respondent interviewed indicated that all families in the community rely on groundwater pumped and stored in the communal water tank. And, focus group results from Campo Verde indicate that, roughly 26 out of the 42 (~62% of all parcels) families in Campo Verde receive their drinking water from this communal pump and tank. Without enough rural credit for complete infrastructure coverage, the other 10 (~24% of all parcels) families in the upper portion of the community can not access this communal tank. To counter this, four of these ten (40%) households have “mini-wells” and pump water to their homes. The remaining 6 (60%) households obtain access to drinking water from ephemeral streams that usually have water through
August (the peak of the dry season), or obtain water from the Rio Preto by filling water barrels and using animal power to transport this water back to their homes. Finally, the last 6 (14% of all parcels) households live by the Preto River and draw water directly from the river or from wells by the river for drinking water.

The second salient feature that emerges is that in contrast to communities in the PAD/DF, communities interviewed in Unaí do not have the same support for drinking water provisions; this point is critical to consider in light of small reservoirs. None of these communities are serviced by a state water provider like CAESB in the PAD/DF-Jardim. Instead, each community has one or two community water pumps that pump groundwater into a community tank. This system is operated by the community, with little outside support. And according to several respondents, no agency assures the reliability of this system.

Perhaps more importantly, however, unlike their counterparts in PAD/DF, when respondents in Unaí were asked to describe drinking water problems, and whether certain people receive priority over others, the grievances were greater in number and more distinct. In Paraíso, for example, two of the three farmers by the river noted that those by the river have a hard time accessing drinking water. As one respondent explained, “people by river have more difficulties”. This respondent noted that people close to the communal tank are better off in this respect. A second respondent noted that when cisterns dry out (due to droughts), the well water quality can go down, and that people by the river need to take water from river. In 2003, for example, this respondent noted that there was less rainfall and so the wells dried out. When asked about challenges in their community, these two farmers also discussed the risks of flooding, years with lower water tables, and the lack of security of being on the communal “water grid” present disadvantages. As one farmer explained, in a recent flood, the Preto River “took with it the rice…along the edge of the river there were problems with flooding”. Taken together, these results suggest a greater vulnerability of drinking water sources.
Interestingly, however, farmers in the upper area of Paraíso, closer to the water tanks also expressed grievances. One farmer noted that in terms of irrigation, those “by the river have an easier time”. However, in terms of drinking water, this respondent noted that it helps to be close to the communal tank. The second respondent thought that those by the river are particularly better off because they “have river water without a problem” for their cattle and for agriculture. And he noted that his parcel is too far from Paraíso’s communal water tank to draw water (because the distance is too long, and therefore too expensive to have a pipe or hose. Therefore his household draws water from a neighbor in the neighboring community, which, though helpful, is still a problem because he has to wait for the neighbor to turn the water on.

In São João Batista, the two main problems with water are water quality and drinking water supply. The one respondent interviewed in this community noted that the biggest problem regarding water is a polluted stream that runs through this community. Just a few kilometers upstream of this community, a state prison dumps raw sewage into the stream, and therefore inhibits farmers from taking their cattle to drink here.

According to this respondent, the second biggest problem relates to drinking water. While every household is connected to the water tank, not every household receives the same supply of drinking water. When asked whether anyone is favored in terms of drinking water, the respondent noted that those closest to the water tank can take more water (this is presumably because of the water pressure). When asked about what problems exist in relation to water, this respondent also added that in general, there is a lack of good distribution of drinking water in the community. Here, this respondent noted that his family and one other family have larger water tanks in their house and therefore receive can obtain more water than others in the community.

In Campo Verde, the situation is perhaps the direst. While the National Institute for Agrarian Reform (INCRA) was supposed to provide infrastructure to build a pump and water tank, as well as provide PVC tubes to transport water to individual households, for unknown20 reasons,

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20 Unknown to myself, the researcher, perhaps not to the community.
they abandoned this project halfway. Instead, the community association was forced to seek its own funding to finish the project. As a result of lack of full funds, only a fraction of the entire community is supplied by water from the groundwater pump.

A secondary source of data reinforces the existing problems with water in these communities. In a study conducted by EMBRAPA\textsuperscript{21} in all \textit{assentamentos} in Unaí, water was the top challenge for Campo Verde\textsuperscript{22}, and the third most important challenge in Paraíso\textsuperscript{23} (EMBRAPA 2005). Water was not listed as a challenge in São João Batista\textsuperscript{24}. In taking a weighted average of these results for all three communities, problems with water appear as the third largest challenge overall, receiving 16\% of the total votes (Figure 4-5).

These results corroborate a greater trend, when looking at results for all 21 \textit{assentamentos} in Unaí. Calculating a relative average for each community surveyed, “Lack of Water” was the single factor receiving the highest votes (Figure 4-6), representing 13\% of all votes. The factor with the highest fraction of the votes (25\%) “Other”, is in fact a compilation of over one dozen single factors. While some of these communities do not necessarily fall within the boundaries of the Preto River Basin, the overall result is still worth noting: water is a critical problem in these communities, and for uses other than irrigation.

The implication of these results are to show that relative to communities with small reservoirs, these communities appear to first need their basic water needs to be solved more adequately. If planners are interested in the potential of small reservoirs in supporting rural

\textsuperscript{21} Source and data is an EMBRAPA colleague who conducted the study. But no citation documentation is available at the time of this writing.

\textsuperscript{22} Top five challenges in order of importance for Campo Verde were: 1) Lack of water (equipment) (38.7\%), 2) Lack of rural credit (arrives late) (22.1\%), 3) Lack of technical assistance (19\%), 4) Machinery is expensive and arrives late (13.6\%), 5) Bad roads (4.6\%).

\textsuperscript{23} Top five challenges in order of importance for Paraíso were: 1) Rural credit arrives late (42.8\%), 2) Machinery is expensive and arrives late (23.6\%), 3) Lack of water (9.9\%), 4) Expensive inputs (8.8\%), 5) Bad quality of roads (8.2\%). Noted in order and in terms of weighted percentage each item received.

\textsuperscript{24} Top five challenges in order of importance for Sao Joao Batista were: 1) Polluted stream water (28\%), 2) Machinery is expensive and arrives late (21.9 \%), 3) Lack of technical assistance (12.1\%), 4) Bad roads for production (11.4\%), and 5) Expensive inputs (7.6\%). Noted in order and in terms of weighted percentage each item received.
livelihoods in this region, it would be worth considering whether they can help to meet drinking water needs.

**Figure 4-5.** Top challenges for the communities of Campo Verde, Paraíso and São João Batista. From totals for each community, I calculated a weighted average for the results of each community.

<table>
<thead>
<tr>
<th>Challenge</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expensive and late machinery</td>
<td>20%</td>
</tr>
<tr>
<td>Lack of water</td>
<td>16%</td>
</tr>
<tr>
<td>Lack of technical assistance</td>
<td>12%</td>
</tr>
<tr>
<td>Polluted stream water</td>
<td>9%</td>
</tr>
<tr>
<td>Bad roads</td>
<td>8%</td>
</tr>
<tr>
<td>Expensive inputs</td>
<td>6%</td>
</tr>
<tr>
<td>Other</td>
<td>7%</td>
</tr>
<tr>
<td>Lack of credit/Difficult Access</td>
<td>22%</td>
</tr>
</tbody>
</table>

Looking at economic livelihoods and drinking water needs in tandem, perhaps small reservoirs could serve multiple purposes, depending on community needs. For example, small reservoirs could serve as more of a storage unit for drinking water. Or, small reservoirs could provide water for livestock. For example, although many farmers draw water for livestock troughs from groundwater (Figure 4-7) or river sources, a central system could benefit those for who water fetching from river, streams or groundwater is more complicated. Whatever the possibilities, results indicate that a comprehensive needs assessment is a critical step before extending small reservoirs.
In addition to complementing current uses, small reservoirs could be used to develop new livelihood strategies, such as irrigated agriculture. This idea is supported, at least initially, with preliminary survey data. When asked what they would do if they had access to more water in the dry
season, a question that was meant to elicit a perceived role for small reservoirs, four out of six (67%) farmers in the non-reservoir communities answered that they would like to have irrigation. The remaining 33% (two out of six) said they would like to have home gardens.

This breakdown, though based on a small sample indicates two interesting points. First, it seems that at least some communities would like to have irrigation and perhaps greater water availability in the dry months for agriculture. Secondly, of the two respondents who said they would like home gardens, both households lack constant access to drinking water. This could reflect the fact that households may focus more on meeting household needs of nutrition than thinking of income producing activities, but there is no certainty in this speculation. In combination, these points underscore the need to have small reservoirs that can serve multiple purposes.

Interestingly, however, when asked what they would do if they had a larger water storage unit, respondents did not necessarily consider using this water for irrigation. Instead, they cited things like having the unit be used for piped water (in Paraíso), or providing more security (Figure 4-8). While this response could seem contradictory, for me it indicates that respondents might not have a full understanding of what a “larger unit” could have meant for them. Thus, the answer is in part due to poor questioning, or to a poor understanding of what the question meant. On another level, however, the response indicates the salience of issues that are currently present for respondents.
Figure 4-8. Responses to the question of why would you want a larger storage unit, asked to respondents in communities without small reservoirs.

Access to Resources

As in the previous chapter, before assuming a potential for livelihood benefits, we must examine the resources available in communities without small reservoirs. These communities do not have the same level of institutional support as do older resettlement communities with small reservoirs. When asked what some of the challenges, respondents in focus groups in Campo Verde noted that INCRA is not present in the communities, nor is there strong technical support. Unlike in the PAD/DF region, respondents discussed that while the primary focus of government agencies has been to build roads, basic housing and limited energy grids, this effort is not fully attended to. Partly because of this, the community association in Paraíso organized for the International Development Bank to loan the community money for a community development project, which includes revamping the water infrastructure system and the housing system.

Secondary sources once again corroborate this general trend of poor institutional support. Returning to Figure 4-5, lack of technical assistance was among the top challenges in the three
communities studied, receiving 12% of the overall votes. Furthermore, the second biggest challenge in these communities was lack of rural credit, or difficulty in accessing it (receiving 22% of the total vote). These results further indicate poor access to institutional and financial resources.

Secondary data sources also indicate that communities require help in entering the market. While EMBRAPA and EMATER offer some assistance in this respect, 1.5% of the votes on indicated that better understanding of the market and how to enter it is necessary. While this percentage is small relative to other figures cited, the point it highlights is significant. Especially if one is to consider the role of irrigation in terms of crop production, these communities may need technical and market assistance in this area.

These points serve to highlight the difficulties that these communities face. If engineers and policy makers are to consider building small reservoirs in these communities, institutional processes and support must be strengthened so as to overcome current limitations. In particular, government support and financing, technical support, and market development and analysis would have to be strengthened (whether for the development of irrigated crops or for the expansion of dairy production).

Despite the lack of institutional and financial resources, communities without small reservoirs do have one positive resource: community associations that could be part of the necessary social system of small reservoir systems. In Paraíso, São João Batista and Campo Verde this is the case. In Paraíso, for example, the community association has been responsible for obtaining additional funding for building a new water supply system. In Campo Verde, the community association was critical in obtaining funding for a drinking water pump and communal tank. Because these community associations tend to be the main organization involved in upholding norms and regulations, and in obtaining financing, the fact that they exist is critical.

Conclusion

In sum, given that there is concern for meeting drinking water needs in communities without small reservoirs, if one is to consider the potential role of small reservoirs, the reservoirs should be
seen as systems that can serve multiple purposes, including providing drinking water, decrease vulnerability in the dry season, etc. And the physical appearance of the small reservoirs may need to be different than in the PAD/DF. If the stream in São João Batista were to be cleaned up (from the dumping of raw sewage from an upstream prison), an earthen dam could presumably be built (hypothetically). However, in Paraíso and Campo Verde, it is unlikely that a dam be built on the Preto River, the nearest free-flowing surface water. Instead, perhaps a weir could divert water into a storage unit. Before assuming that any of these things could result in livelihood benefits, however, one must ask the now obvious question: are the necessary institutional and economic resources available in these communities?
CHAPTER 5: CONCLUSION AND POLICY RECOMMENDATIONS

The above results indicate not only the important role of irrigation for some communities, but the significant role that small reservoirs play in this process. In addition, non-economic benefits such as water for livestock and the nutritional supplement of vegetables also exist. Because more small reservoirs are planned for the basin, these benefits signal the importance of siting small reservoirs in places where rural farming communities can continue to benefit.

The degree to which this support can be better accessed or provided is likely to affect whether small reservoirs can have a real impact. In communities with small reservoirs, only some farmers have the ability to command and access the benefits of small reservoirs. These farmers receive livelihood benefits and improved socioeconomic status. Others, because of their physical location along the canal, or because they do not have “legal” access to the canal water do not. In communities without small reservoirs, farmers are more stressed and are unable to command access to proper outside institutional and economic support. Thus, one must not only ask: what are the livelihood benefits of small reservoirs, one must ask how access to resources affects whether these benefits exist.

Issues of access also highlight a dependency on outside resources to derive benefits from small reservoirs. Since small reservoirs were first built through today, a series of government institutions have been involved in their development—government lending agencies, EMATER extension agents, etc. If small reservoirs continue to be developed as they have been in the past, it is unlikely that the systems can function with less outside support, at least in the initial years. If this is the case, policy makers must understand that the development of small reservoirs requires a commitment to providing necessary resources, even if sporadically over time. If the systems could function with less outside support, this could potentially be a more self-sustaining process. This situation would require that planners and engineers re-conceive of how the systems are developed.

Farmers who use small reservoirs noted that it would benefit others to access small reservoirs. Because of this, it is worth considering whether changes in water supply or water
management could occur. How could increasing access happen? Perhaps, it is merely a matter of regulating water use, so that more people can use the canal water to cover their demands. In this case, this would require focusing on social aspects of water management. If there simply is physically not enough water supply this raises two possibilities: 1) It may not be possible to have more farmers benefit from the small reservoirs, or 2) Engineering and management of the reservoirs must be addressed to see if the water supply can be purveyed and managed.

What if the present day pattern of irrigation (i.e. some use the small reservoir system, others use alternative sources of irrigation water) is the result of system stability? What if farmers have figured out how best to function within the limitations of their water system? In this case, no amount of social changes could induce changes for other farmers. Only the building of additional storage could help. To firmly answer this question, one must conduct an analysis of total water supply in these systems, and total water demand, and model what changes in irrigation behavior would result.

Beyond addressing access, it may be necessary to re-conceptualize how small reservoirs are built, and what purposes they serve. Communities without small reservoirs lack meeting basic drinking water needs and accessing proper resources. Given proper institutional and technical support (which until now are not easily accessed) small reservoirs could be incorporated into rural livelihoods, potentially providing benefits in the form of meeting basic needs, and supporting and expanding economic livelihoods. This could be the case, especially if small reservoirs are developed as multi-purpose systems. Despite this reality, the distinction between assentamentos in Unaí versus PAD/DF must be made. In Unaí, most of these communities have been established in the last ten to fifteen years, not twenty or thirty like in the PAD/DF. Thus, the state of “development” and resource support could be due to this fact. Their characteristics could also be due to differences in how municipal governments support newly developed communities in the two regions.
Moving from this broad lens, we can now consider specific policy recommendations. These recommendations are preliminary\textsuperscript{25}. In addition, they are specific to the realities observed in the Preto River Basin.

\textit{Policy Recommendation 1}

Researchers, agricultural extension agents and community associations should consider whether they seek to augment access to benefits from small reservoirs. In doing so, they should ask: Can reservoirs be operated in a way that would increase access to the canal water, or can the water supply be distributed differently, still producing the same or greater positive livelihood results? Do additional reservoirs need to be built in these communities to cover increased demands? Does the proper farmer will and institutional support exist to support any of these changes?

\textit{Policy Recommendation 2}

New small reservoir building campaigns should include a transparent education campaign that describes the benefits of having these small reservoirs so that people are better informed whether they want to cost share, and therefore have access to small reservoirs.

\textit{Policy Recommendation 3}

Small reservoirs should be conceived as systems that could provide multiple purposes, not just irrigation. In this case, communities could use small reservoirs for drinking water, milk production and irrigation. Over time, the use of these systems could shift, depending on community demands.

\textit{Policy Recommendation 4}

Communities without small reservoirs need stronger institutional support, in the form of better access to rural credit, better follow through by INCRA (the National Institute for Agrarian Reform) in setting up housing, road and drinking water infrastructure. Unless these basic forms of community development support are received, these communities are unlikely to be in a position to benefit from small reservoirs.

\textsuperscript{25} Because this study was developed as a baseline study, it is my hope that the findings and policy recommendations mentioned above may be further studied, corroborated and/or revised. Small reservoirs have potential for the Preto River Basin, but the gamut of contingencies must be openly addressed.
Policy Recommendation 5

New small reservoirs should be sited so as to improve livelihoods of rural farming communities. At the time of this research, roughly one dozen new small reservoirs were being proposed for the Preto River Basin. All 15 were targeted for the use by large farmers. If these reservoirs, or others like them are to be built, they should be sited so as to increase the overall socio-economic well-being. For this, current policy debates and small reservoir planning in the basin should become more transparent and equitable.

Policy Recommendation 6

Before any final decisions are made regarding whether to build more small reservoirs, communities should be involved and consulted regarding their needs and desires in terms of water management issues.

Policy Recommendation 7

Beyond community-level dynamics, research and planners should address the downstream effects of these small reservoirs. What is the overall system effect on the Preto River of these multiple small reservoirs, from both socioeconomic and hydrologic perspectives?
APPENDICES

APPENDIX 2-A: More Background on the São Francisco River Basins

Background
The São Francisco River Basin is of great importance to Brazil, not only because of the large volume of water it conveys to a semi-arid region but also because of its potential water resources and its historic and economic contribution to the region (ANA 2006). Given the São Francisco’s prominence in current day Brazilian water politics, it is helpful to situate the Preto River Basin in relation to the São Francisco basin.

In recent years, the São Francisco River Basin has received increase attention. Running from southwest to northeast, the Basin spans a diversity of socioeconomic conditions, land-use patterns and ecologic components. The Basin captures a range of socioeconomic conditions, from wealthy industrial and urban centers, to poverty-stricken arid northeast. Similarly, the Basin traverses a range of Brazilian ecosystems, from savannah-like cerrados to coastal mangroves.

Water use in the basin can be a source of conflict. For example, the São Francisco River has hydroelectric dams, which are oftentimes contested between the power sector and environmentalists. Most recently, government plans to divert the river’s water’s has become a highly contested policy—some say is for the poor in arid areas, while others argue that this water will only be used for industrial agriculture further north, have caused great polemic.

Hydrology and General Characteristics
The São Francisco River Basin drains an area of 639,920 km² (ANA et al. 2004), an area representing roughly 7.5% of Brazil’s area (CBHSF 2006). Running in a northeast direction, the São Francisco River is 2,863 kilometers in length and spans the states of Alagoas (2.2% of the total area), Bahia (48.2%), Goias (.5%), Minas Gerais (36.8%), Pernambuco (10.9%) and Segipe (1.2%), as well as the Federal District (.2%). The Basin contains 504 municipalities, representing 9% of all Brazilian municipalities (CBHSF 2006). At its mouth, the long term mean discharge of the SF River varies from 2,850 to 3,360 m³/s.

Physiography and Climate
Due to its length and the many environments through which it flows, the SF Basin is divided into four main physiographic sections: the Upper, the Middle, the Lower-middle and the Lower (ANA et al 2004) (Figure 1). These sections are characterized by a distinct combination of climate, geology, geomorphology, hydrology and other physiographic criteria (See Table 1).

Annual mean precipitation in the SF Basin varies from 400 to 1,800 millimeters. And given its vast expanse, the basin contains a great diversity of climates, going from a humid climate, in the Southern and Western parts, to a semi-arid climate, in the northeastern section.

Biomes and Vegetation
The principle biomes and types of vegetation in the Basin vary by physiographic section. The Upper section is characterized by cerrados, or dense savannah-like ecosystems, and remnant forests. The Middle section has cerrados, caatinga (stunted scrub growth in semi arid areas) and high altitude forests. The lower-middle portion is mainly caatinga, and the lower portion includes semi-deciduous, coastal vegetation, including mangroves (ANA et al. 2004).
Figure 1. Physiographic boundaries of the São Francisco River Basin

Table 1. Summary characteristics of the São Francisco River Basin.

<table>
<thead>
<tr>
<th></th>
<th>Upper</th>
<th>Middle</th>
<th>Lower-Middle</th>
<th>Lower</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Area (km²) (%) Total Area</strong></td>
<td>99,387 (15.6%)</td>
<td>401,559 (63%)</td>
<td>115,987 (18.2%)</td>
<td>19,987 (3.1%)</td>
</tr>
<tr>
<td><strong>Length of main stem</strong></td>
<td>1,003</td>
<td>1,152</td>
<td>568</td>
<td>140</td>
</tr>
<tr>
<td><strong>Population</strong></td>
<td>6,489,402</td>
<td>3,364,383</td>
<td>2,021,289</td>
<td>1,422,881</td>
</tr>
<tr>
<td><strong>Prevailing climate</strong></td>
<td>Tropical humid and temperate</td>
<td>Tropical semi-arid and sub humid dry</td>
<td>Semi-arid and arid</td>
<td>Sub-humid</td>
</tr>
<tr>
<td><strong>Elevation (m)</strong></td>
<td>600-1600</td>
<td>500-1500</td>
<td>200-800</td>
<td>Sea-level-480</td>
</tr>
<tr>
<td><strong>Median annual rainfall (mm)</strong></td>
<td>1,100-2000</td>
<td>600-1400</td>
<td>350-800</td>
<td>350-1500</td>
</tr>
<tr>
<td><strong>Contribution to flow (%)</strong></td>
<td>41.7</td>
<td>54.6</td>
<td>1.9</td>
<td>1.8</td>
</tr>
<tr>
<td><strong>Predominant vegetation</strong></td>
<td>Cerrados and remnant forest</td>
<td>Cerrados, caatinga, small, high altitude forest</td>
<td>Caatinga</td>
<td>Semi-deciduous seasonal forest, mangrove swamps and coastal vegetation</td>
</tr>
</tbody>
</table>
Rural Livelihoods and Access to Resources in Relation to Small Reservoirs

<table>
<thead>
<tr>
<th>Irrigated area (ha and %)</th>
<th>44,091 (12.9%)</th>
<th>170,760 (49.8%)</th>
<th>93,180 (27.2%)</th>
<th>34,681 (10.1%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major economic activities</td>
<td>Industry, mining and livestock</td>
<td>Farming, livestock, industry and aquaculture</td>
<td>Farming, livestock, power generation, mining and agribusiness</td>
<td>Farming, livestock, fishing and aquaculture</td>
</tr>
<tr>
<td>Water Resources Availability (m3/person/year)</td>
<td>2,000-10,000</td>
<td>&lt;500-&gt;10,000</td>
<td>&lt;500-2,000</td>
<td>1,000-10,000</td>
</tr>
<tr>
<td>HDI</td>
<td>.549-.802</td>
<td>.343-.724</td>
<td>.438-.664</td>
<td>.364-.534</td>
</tr>
</tbody>
</table>

**Socioeconomics**

According to the GEF (2004), roughly 13,297,95526 people inhabit the Basin. A range of socioeconomic conditions exist in the basin, from extreme rural poverty to lucrative industry and agriculture. The United Nations Human Development Index (HDI) varies from 0.823 in the upper SF to 0.538 in lower portions of the basin. The major economic activities for each portion of the basin are tabulated in Table 1.

**Water Demand**

The total water demand in the basin is approximately 203 cubic meters per second, representing 9% of total Brazilian demand. The main uses of water in the basin include urban, irrigation, livestock and industrial purposes (Table 2). The highest demands for water occur in the Middle SF Basin. The highest demand to availability ratio, amounting to 19.8% occurs in the Upper SF, followed by the Middle SF (8.5%), the Lower-Middle (6.8%) and the Lower SF (2.1%).

<table>
<thead>
<tr>
<th>Type of demand</th>
<th>Demand (m³/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entire Basin</td>
<td>636,920</td>
</tr>
<tr>
<td>Upper</td>
<td>35.3</td>
</tr>
<tr>
<td>Middle</td>
<td>8.7</td>
</tr>
<tr>
<td>Lower-Middle</td>
<td>7.8</td>
</tr>
<tr>
<td>Lower</td>
<td>12.9</td>
</tr>
<tr>
<td>Irrigation demand</td>
<td>138.1</td>
</tr>
<tr>
<td>Total Demand</td>
<td>202.8</td>
</tr>
</tbody>
</table>

**Governance**

From a jurisdictional standpoint, the political-administrative organization of the SF Basin includes the federal government, state and Federal District authorities, and municipal authorities,

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26 This figure varies depending on source. The official website of the Sao Francisco River Basin committee (http://www.cbhsaofrancisco.org.br/abacia.php) cites 16.14 million people
which according to the Brazilian Constitution, are autonomous within the Brazilian Federation (ANA et al 2004). Despite this complex cross-over of government institutions, Law 9,433/97 establishes that the basic unit for water-resources management is the hydrographic basin, making negotiation across jurisdictions imperative.

To this end, in June of 2001, the São Francisco River Basin Committee (CBHSF) was created. As stated by the Basin Committee, some of the challenges to overcome are:

- Define strategies to solve conflicts between different water users—energy, irrigation, tourism, navigation, urban and rural demand, etc.
- Resolve conflicts between demand for consumptive uses and lack of water in critical periods
- Implement proper sewage treatment for domestic and industrial sources
- Rationalize the use of water for irrigation in the Middle and Lower Middle portions
- Establish strategies that prevent floods and protect areas that are subject to flooding
- Define proper soil-use/land-use strategy

In tandem with these goals, the Challenge Program for Food and Water, a basin-wide research endeavor, notes that the Basin’s priorities should also include:

- Identifying and quantifying multiple uses of water in micro-basins, sub-basins and the overall basin
- Improving water productivity, for irrigated and rain fed agriculture and fisheries
- Managing water resources in an integrated and sustainable way
- Alleviating poverty, contributing to water and food security
- Assisting rural communities and other stakeholders in the basin and sub-basins to rationalize water use
APPENDIX 2-B: Additional Information on the Preto River Basin and Communities Studied

Water-Related Institutions and Organizations Functioning Within the Basin

Throughout the Basin, a series of organizations work water-related issues at the community level. These institutions can be outside institutions that come to serve the local communities, community-based institutions, or a hybrid of both outside-inside organizations, as will be explained. These institutions can be grouped under the following heading: 1) Government agencies, 2) External finance institutions, that are not government-based, and 3) Local community organizations.

Government: Federal, State and Local Agencies

In communities such as Lamarão, Capão Seco, Nucleo Rural Jardim and Buriti Vermelho, the government’s presence (as relates to water) is mainly historic. Municipal and federal government officials helped with the financing of the small reservoirs and canals in initial and later stages. And, the government is still involved in general infrastructure support, such as road maintenance, and roadside detention basins.

In communities such as Paraíso, Campo Verde and São João Batista, national government institutes have been more recently involved in the direct resettlement of rural communities to the specific locals, and in the initial infrastructure support, such as roads and housing. Here, INCRA, the National Institute of Colonization and Agrarian Reform has been an important player, even if respondents note that INCRA’s follow through is not always great.

In all communities visited, EMATER, the state-sponsored rural agricultural extension agency is present, both for the Federal District and the state of Minas Gerais (the study did not look at Goiás). Overall, respondents noted that EMATER helps in agricultural support. However, in some communities, EMATER can be more involved with water issues, as needed. In Buriti Vermelho, for instance, some respondents noted that EMATER helps calculate water use rates (energy costs).

For communities in the Federal District (Capão Seco, Lamarão, Buriti Vermelho and Nucleo Rural Jardim), an important state-level body is CAESB, the Brasilia Sanitation Company. With the exception of Capão Seco, where CAESB only functions in the AgroVila, CAESB provides rural communities with domestic water provisions. In all three communities, CAESB has installed a large community water storage tank, a groundwater pump, and pipe systems that reach all houses in the community. In all cases, CAESB employs a local community member, the zelador, to take care of turning the pump on and off, collecting payment fees (for the energy), and alerting the company of any distribution or management problems.

For communities visited in Minas Gerais (Paraíso, Campo Verde and São João Batista), no such company such as CAESB exists to service the community. In Campo Verde, INCRA was supposed to help with the financing of this infrastructure, but stopped half way. In Paraíso, INCRA helped set up the infrastructure, but no longer manages it. In all three communities, community members and/or the community associations have stepped in to manage or improve the situation.

Local Community Organizations

Several local, community-organized organizations exist within the communities interviewed. These are: the general community associations, and in some cases water user associations. In all communities that were interviewed, a community association exists, and the officials are democratically elected. In communities with small reservoirs and market-based production, respondents noted that the main function of this organization is to organize production. For example, in Lamarão and Buriti Vermelho the association organizes the sharing of agricultural equipment, or the transport of goods to market. In all communities, respondents noted that the community association helps in community decision making, in obtaining financing (though this answer was particularly prominent in the Minas Gerais communities), and in community infrastructure (i.e. building roads).
These community organizations are involved in water issues in several ways. In some cases, such as in Buriti Vermelho, the association helps administer water and payment for domestic water. In other communities, such as in Campo Verde and Paraiso, the association is involved in obtaining financing for water-related infrastructure (i.e. pumps and tanks).

In communities with small reservoirs, formal and informal “water user associations” exist. In Nucleo Rural Jardim, for example, after the canals were lined, the twelve farmers that use the canal address canal problems and water amongst themselves.

While the general roles of these community associations do not vary much from one community to the other, the degree to which these associations function with transparency and equity seems to vary. In Lamerão one of the two farmers noted that only a small circle of farmers are benefited by the association, and that in particular the community association does not know how to distribute canal water equitably. In Campo Verde, on the other hand, the current president is very inclusive in her organizing. In all communities, the president seems to be the primary person in the community association, indicating that perhaps the association has concentrated power and responsibilities to one person.

**External Funding Organizations**

In some cases communities have had to look for external funding sources. Such is the case in Paraíso, where the president of the community association secured financing in recent years from the International Development Bank (BID). As of 2003, BID had committed to financing additional domestic water wells and pumps, as well as a new distribution system of pipes for all households, not only the few that are currently accessing the communal water tanks.

**Others**

A host of other organizations are in the background of community-related water issues, such as the National Water Agency (ANA), and CODEVASF (The São Francisco and Paranaíba Valley Development Company). These agencies, though playing a critical role at a basin and federal level, are less visible at the community level. Institutional questionnaires indicated that as water allocation and water pricing gains prominence, the role of these agencies will increase.

Finally, though respondents did not directly note this, EMBRAPA, the national-level Brazilian Agricultural Research Corporation sometimes conducts research in community areas. Here, the involvement in water issues is more often than not, indirect.

The following sections describe the main socioeconomic features, land-use and water-use characteristics of each community that I studied.

**Communities Studied**

**Buriti Vermelho**

Located roughly 60 kilometers from Brasilia, the community of Buriti Vermelho has 32 parcels of land. Because some have been combined and others divided among family, there are thirty parcels functioning as independent units. Parcels range from 2 hectares to 6 hectares, averaging 3.47 hectares. Approximately 30 families live in Buriti Vermelho, contributing to a rough total population of 150. Some farmers have combined several parcels into one. For these farmers, either they have merged land with another family member, or buy the right to “rent” the land from the “owner” of the contract/lease.

The community of Buriti has four small reservoirs, two of which are used for irrigated agriculture, the other two of which are not in use (Figure 2). Each of the two utilized reservoirs has one canal, which serve different parts of the community. The canal that comes from the first reservoir splits into two by the time it reaches parcels within the community.
Figure 2. Satellite image of the community of Buriti Vermelho. The community is highlighted in a red box-like area. Small yellow boxes represent sites of diversion from main canals to individual farms. While four small reservoirs are visible, only two are in use. Center-pivot irrigated agriculture surrounds the community.

While the reservoirs in Buriti Vermelho were first built by the government starting in the late 1970s, from 1995-1996, additional funds were obtained to line the canals and repair the reservoirs. In return for the government building these reservoirs and canal systems, farmers were supposed to purchase more efficient irrigation equipment (Rodrigues et al 2004). This policy was only partially successful, as only some farmers kept these more efficient technologies. At this time, the community also decided that only those families which helped build the canal could have access to it.

Today, thirteen of the thirty parcels do not use canal water (43%). Of these thirteen, five only have rain fed agriculture, and eight irrigate with water from other sources (streams and springs). The remaining 17 parcels (57%) have irrigated agriculture.

The community has a Community Association that, among other things, supports the sale of vegetable crops to nearby markets. The formal, and main source of drinking water comes from CAESB’s groundwater pump, which is then stored in the communal water tank. Buriti Vermelho has an elementary school, and less than one quarter kilometer of paved road, that was built with funding obtained by the current president.

**Capão Seco**

The community of Capão Seco is approximately 70 kilometers from Brasilia. Currently 28 families live in the rural community of Capão Seco, located next to an *AgroVila*[^27], a neighboring community.

[^27]: This study does not focus on the Agro Vilas, only on the farming community.
community that has roads and public infrastructure (e.g. paved roads, water service, etc). Of the 28 farmers, four farmers use irrigation from an elevated weir for the production of vegetables, while the remaining have rain-fed agriculture, and small-scale economic enterprises (Rosana 2004). The weir is built on a stream. Besides the Agro Vila, the community is surrounded by other large farmers, some of whom also use this same source of surface water. Currently, the community does not have a community association, but it is seeking to set one up.

Lamarão
The community of Lamarão has both a community of rural farmers and an Agro Vila. For the purposes of this study, only the farming community is considered. In fact, it is a separate land unit than the Agro Vila. The farming portion of the community is comprised of 18 parcels of land. Roughly 40 non-agricultural-based families live in the Agro Vila.

Roughly twelve out of the eighteen farmers in Lamarão use irrigation for the production of vegetables. These farmers obtain water for irrigation from a small reservoir which is transported via an unlined canal, both of which were financed by the government, and built in 1982. The small reservoir was built on a private, large-landholder’s property. Because of this, it is under the jurisdiction of the government, the private landholder is under no obligation to manage or take care of the reservoir, but his cattle can drink from the reservoir, and in fact are a cause of concern for community members downstream, due to erosion. The remaining six farms practice subsistence agriculture, or other forms of livelihoods.

The community has a Community Association, whose main function is to organize the selling of vegetables to nearby markets, and administer the use of communal agricultural equipment. The community receives its formal drinking water from a groundwater well which was drilled by CAESB. As of 2005, the well water was condemned as contaminated, and therefore CAESB was drilling a new well on one of the farmer’s properties.

Nucleo Rural Jardim
The community of Nucleo Rural Jardim is about 220 hectares in area, and has 46 parcels. The community also has a 15 hectare “administrative area”, composed of 6 hectares for public use (e.g. school, church, general store, health clinic, rural extension agency), and 9 hectares which have been occupied by landless peoples. As indicated in interviews with agricultural extension agents, and landless residents, these families suffer from poor sanitation, contaminated drinking water and no formal electricity. The community uses two small reservoirs for irrigated agriculture.

Aside from the small reservoirs, four farms draw water directly from nearby streams or springs for irrigation. Of these, two parcels use a private small reservoir (Figures 3 and 4) known as Capão da Erva. This reservoir was built by one farmer, who shares its use with his neighbor. The community has a Community Association, whose main task is to organize the distribution and payment of domestic water services, which come from a CAESB water pump and tank.

The three communities interviewed for this study, Campo Verde, Paraíso and São João Batista, were all resettlement communities, each established in the early 1990s. As a group, these three communities different from their counterparts in the PAD/DF region, not only in their stage of establishment, but in the dominant land-uses and general livelihood patterns. As with the previous section, the following sections describe the main socioeconomic and land and water use characteristics of each of the three communities.

Campo Verde
Located roughly 45 minutes from the city of Unaí, and approximately 35 kilometers, the community of Campo Verde, was established by INCRA (the National Institute for colonization and Agrarian Reform) in the early 1990s. Campo Verde is divided into 42 parcels. Parcels in the community are located either along the Preto River (8 kilometers from the community center), and those which are far from the river, but close to the water tower, community center and dirt road that connects to other communities, and eventually the main highway. The majority of community
members have chosen to live away from the River, noting that this is too far for children to catch the school bus. This community has a diesel-powered pump that pumps groundwater to a central water tank. While the majority of the community practices subsistence agriculture, some of the production is sold. In addition, the community produces approximately 9,000 liters of milk per month.

While INCRA was supposed to be responsible for the establishment of the community’s drinking water system, it abandoned the project half way. Instead, the community association sought funding to finish building the drinking water system.

Paraíso

In 1990, INCRA created the resettlement community of Paraíso in the municipality of Unaí. Paraíso is located, roughly 15 kilometers from the community of Campo Verde. Paraíso has 78 families (and parcels), and a population of 308 people\(^{28}\). Parcels range from 33 to 55 hectares, with an average parcel size of 35 hectares. As of 2003, 78% of the parcels were owned by landholders via INCRA’s resettlement policy, 3% were inhabited by residents who had taken over the land “illegally”, and 19% of parcels had been bought from farmers who obtained the land through INCRA, but decided to leave the community (Coomap 2003). Prior to being converted to a resettlement community, the land was part of an extensive pasture, owned by one single landholder. Today, most of the land is previously degraded pasture.

The physical location of parcels in the community varies widely. Thirty-three of these parcels border the Rio Preto River (Paraíso is downstream of Unaí). Twenty-three parcels are dispersed in the upper cerrados portion of the community, 7 by the Riberão Barriguda and 15 between the two nature reserves and 23 in the cerrados area (Coomap 2003).

The main source of income for farmers in Paraíso is milk. On average, the community produces 45,000 liters of milk per month. Other economic activities include having fruit orchards, selling carbon (from deforesting their property), working as day laborers and practicing subsistence agriculture (oftentimes selling the excess production).

As with Campo Verde, the community has a community association which secures financing for community development projects, and oversees various aspects of community decision-making. In addition to this association, several economic associations exist: such as artisans cooperative, a Baru nut cooperative, and the milk cooperative. The milk cooperative is particularly important for the community’s dairy production as it owns 4 refrigeration tanks for milk, and sells milk cooperatively to a nearby company.

São João Batista

Roughly 25 kilometers from Unaí, off of the paved highway, the community of São João Batista is a resettlement community that was established by the Banco da Terra, as opposed to INCRA. Approximately 20 families live in the community, totaling to roughly 100 people. The community obtains drinking and agricultural water from a groundwater pump. The nearby stream that borders the community is contaminated by raw sewage that comes from a state prison, just upstream of the community. The community has a community association whose leadership has alternated between the two dominant families in the community, and is critiqued by EMATER extension agents as nepotistic and undemocratic.

\(^{28}\) Census level data for this community is taken from a COOMAP 2003 survey of the community. The president of the community let me look at the document, but there was no citation documentation available.
APPENDIX 3-A: Maintenance Problems with Small Reservoirs

Problems with Maintenance

In communities where there are earthen canals (i.e. Lamarão), some farmers noted that erosion is a major problem. In Lamarão, for example, farmers noted that because the canal is open, there is erosion from both animals and rains. Furthermore, these same farmers noted that due to upstream deforestation, the small reservoir receives additional effects of erosion.
WORKS CITED


