Characterizing Rural Landscapes and Communities through Integrated Information: An Application to Yemen

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Rural development planning in Yemen suffers from a lack of integrated analysis and monitoring to combine natural resource and land use indicators with socio-economic data. This paper takes a first step in this direction by undertaking an integrated assessment of the constraints and opportunities for agricultural development in rural areas. The analysis includes an assessment of the bio-physical environment in a selected study site; a description of rural livelihoods based on household data; and an assessment of rural institutions. Taken together, the findings yield a coherent assessment that water scarcity is the main constraint facing rural development in Yemen's rain-fed highlands; that this key constraint is further exacerbated by changes in the social structure and livelihood strategies of households such as seasonal male migration; however, lastly, we find that rural institutions offer a strong mechanism for participatory development that could support natural resource management and rural development.

1. Introduction

This paper analyzes the constraints and opportunities for agricultural development in rural Yemen, using a three-pronged approach to study the bio-physical environment, socio-economic data, and institutions. Accelerated economic growth in Yemen's rural areas is critical to reducing poverty and improving food and nutrition security. Yemen, with a population of 25 million, is one of the poorest countries in the world. About 68 percent of the population lives in rural areas where the poverty rate is about 40 percent compared to 20 percent in urban areas (World Bank, 2014). The country ranks 154 out of 187 countries in the 2014 Human Development Index (UNDP, 2014), and 72 out of 78 countries in the 2013 Global Hunger Index (IFPRI, 2013). It is among the ten countries in the world with the highest rates of food insecurity, and it has the third highest level of malnutrition in the world.

Agriculture will be a critical component of any rural development program in Yemen. For poor people in Yemen, who mostly live in rural areas, agriculture is particularly important as a source of food and income. Agriculture is also a key sector in Yemen's economy, contributing 19.5 percent to the nation's GDP. Agriculture is the third-largest economic sector, after services and industry (including oil). Agriculture is the main source of income for 73 percent of the population either directly (33 percent) or indirectly through the services and industries connected to the agricultural economy, and employs more than half (54 percent) of the labor force. Yemen's youthful age structure means that many more jobs will be needed, and agriculture offers important opportunities for increasing employment, productivity, and income.

Growth in Yemeni agriculture is, however, hampered by its reliance on a weak natural resource base – specifically land fragmentation and water scarcity. Only 3% of Yemen's land area is considered suitable for cultivation, and with shrinking plot sizes averaging less than 1 ha (World Food Programme, 2009). In terms of water, Yemen is an arid country and agriculture accounts for some 93 percent of water use. With no permanent rivers, most of the water for agriculture comes from rainfall in the mountainous areas, groundwater, spate flows in otherwise dry riverbeds (wadis), and springs.

To tackle these constraints on rural development, the Government of Yemen and its development partners have developed strategies covering areas such as agriculture, water, and food security security (see, for example, Government of Yemen, 2011; 2012). .

However, rural development programs in Yemen have suffered from a lack of integrated analysis and monitoring that combines natural resource and land use indicators with socio-economic data. To adequately address the problems, policy-makers need to improve their understanding of the bio-physical environment in which rural households pursue their livelihoods. In particular, development practitioners need information about geographic, economic, and institutional factors that need to be taken into account when assessing the long-term viability and sustainability of planned projects.

Therefore, this study links the understanding of the poverty/social context to the "landscape" which determines livelihood opportunities and vulnerability to rainfall shocks. The motivation behind this study's approach to understanding resilience of rural communities is that social factors, climate variability and eventual climate change will impose increasing pressures on the natural resource base of Yemen's rural areas, impacting poverty, livelihood strategies, vulnerability and resilience of rural communities.

The next section presents the background and the rationale for the approach used in the study, while the third major section focuses on the data, methodology, and findings from the analysis. The paper concludes by summarizing the key findings and laying out a few some policy recommendations.

2. Background on the Three Study Components

2.1. Characterizing Bio-Physical Contexts

2.1.1. Agricultural Development within a Bio-Physical Environment

In their agricultural activities, poor people around the world depend heavily on the available natural resource base available to them (Pinstrup-Andersen and Pandya-Lorch, 1994). Livelihood strategies, therefore, are developed and maintained in the context of natural capital[1], and the degree of diversification or resilience inherent in a livelihood strategy is dependent on the availability of natural resources (Scoones, 1998).

In the context of this study, since Yemeni agriculture is mostly reliant on rainfall for water, understanding the causes of vulnerability and sources of resilience in rural areas requires

[1] Natural capital is obviously not the only or most critical form of capital. Others types, such as financial, social, or human capital, are needed to interact with natural capital in ensuring successful outcomes in agricultural production.

linking the understanding of the socio-economic context to the "landscape" which determines livelihood opportunities and vulnerability to rainfall shocks. In the Yemeni context, rainfed agriculture includes water harvesting that collects run-off from larger areas and channels it to fields. Irrigation from groundwater, springs, and spate flows is important in specific locations where water is available, but rainfed, (non-irrigated,) agriculture plays a crucial role in livelihoods, particularly for poorer households. A landscape approach is key since resilience is determined by how households and communities engage with their biophysical environment to support their livelihoods, and how they are able to adjust to changes which come from either the social (population growth, intra and inter-migration) or the biophysical (land degradation, climate change) contexts.

Therefore, the challenge in this study was to develop and examine information that would summarize individual community responses to the environment. This information would need to address the following questions: What are the important elements in the bio-physical environment that capture the status of the natural resource base on which rural communities make their living? How does the physical environment set the stage for the communities? And how do the rural households cope with the demands of that physical environment, especially in a dynamic context? In this study, we address these questions using data in a geographic information systems (GIS) platform combined with descriptive socioeconomic data from household surveys. As an additional step, we provide an assessment of rural institutions, which reflect the social structures within which the households pursue their livelihoods.

2.1.2. Applications of the Landscape Approach in Other Countries

Policy-makers constantly need to undertake appropriate simulations of likely impacts of changes in available natural resources on critical sectors for economic development at relevant spatial and time scales. Landscape scale planning and "Decision Support Frameworks" are practical tools that can be used by governments and policy makers for this task. Cross sector (inter-Ministry) data integration and linkages are essential for effective local to national to regional/global analyses, synthesis, scenarios and decision-making.

Dynamic data and information frameworks for landscape planning have been applied in diverse contexts such as the Zambezi Basin in Mozambique, the Aral Sea Basin in Central Europe, the Mekong Basin in China, and in countries such as Brazil (Espirito Santo State), Bhutan (in the Himalayas). In the context of international development assistance, the World Bank is providing technical assistance and limited project financing to assist client countries to develop their own Dynamic Information Frameworks for landscape scale management of natural resources and to conduct impact simulations for prioritizing investments for enhanced resilience to climate change.

2.2. Integrating Bio-Physical and Socio-Economic Data

Integrating data from the physical sciences on natural resource availability with socio-economic data, such as household survey results, is widely considered to be a laudable goal by policy-makers, development practitioners and researchers (Sullivan and Meigh, 2007; Fischer, 2001). However, this type of integration is not yet a common approach to understanding the constraints and opportunities faced by rural communities, Amissah-Arthur, Mougenot and Loireau (2000) have applied the approach in the Sahel and Xie et al. (2005) use an integrated research method to study land use change in China. The limitations on a wider application of this approach of integrating data are mostly due to complexities with the relative scales of data collection within space and time.

2.3. Assessing Institutional Strengths and Weaknesses

Institutions provide the "rules of the game" within which rural people make their livelihoods, shaping access to land and water, structuring collective action to provide local goods and services, and offering methods for resolving disputes and maintaining forms of social order. Organizations, such as associations, usually have distinct boundaries between members and nonmembers, and internal arrangements of roles and responsibilities. Other social structures may form networks of relationships, dynamically shifting over time as people make and modify friendships, business relationships, political alliances and other political, economic, or personal linkages. This paper builds on earlier work mapping rural institutions in Yemen to assess challenges and opportunities for rural institutions.

3. Analysis and Findings

3.1. Data and Methods

This paper identifies and undertakes three assessments: characterizing the bio-physical environment, describing rural livelihood strategies, and assessing rural institutions. The methodology is used to provide answers to the following research questions: i) How has poverty in rural Yemen changed over time?; ii) How have the economic, social and bio-physical shocks from changes in rainfall evolved with time in the communities?; iii) How have the livelihood strategies evolved as a result of the rainfall shocks?; iv) How has the vulnerability of communities changed?; iv)What are the coping strategies available to rural households that can help determine their resilience to rainfall shocks and poverty?"

3.2. Analysis of the Bio-Physical Context

The analysis of the bio-physical environment involved collecting and examining available information in the form of Geographic Information System (GIS) datasets. Descriptions of the environment can be thought of as a "sandwich," of multiple layers of information, each representing a key part of the landscape. Layers include the physical relief (the topography), soils (their types and ultimately properties), vegetation (land-use and land-use change), and finally water resources. Superimposed on this physical world, then, are the communities that live there, and their economic and social attributes. There were seven tasks involved in describing the bio-physical environment.

3.2.1. Study Area

Six sites within the Sana'a basin were selected for this study . The Sana'a basin (the basin is defined as the drainage basin, meaning that rain falling in the basin flows to a common drainage point and to, for example, the next basin over) is a region already suffering from extreme water stress both in terms of rain water and groundwater reserves. Climate models predict that this scenario is going to further deteriorate under the impacts of climate change (decreasing rainfall and increasing temperature). With a population growth rate of seven percent, and extensive pumping for irrigation, Sana'a's water sources are being rapidly depleted. This creates important implications for water resource demand and management. Figures 1 and 2 delineate the focus areas of the study.

3.2.2. Digital Elevation Model

A Digital Elevation Model (DEM) established the topography of the Sana'a basin. This describes the "physical structure" of a region (Sana'a basin) i.e. what the elevation and slope gradients are, where drainage patterns culminating in river networks are, etc.

3.2.3. Soils Map

Soil maps include not only the "names" of soils, but, more importantly, the properties of the soil (depth, texture, chemical composition). At the regional scale, global data sources for soils showed little differentiation across the region. At the scale of the Sana'a basin, two different classifications (Russian and American classification schemes) presented a more refined view of the basin. Interestingly, there are considerable differences between the two classifications depending on the interpretation of the soil names.

3.2.4. Land-use and Land-Use Change (LU/LUC)

How land is used (LU) relative to what is available is a key determinant of rural livelihoods. Evaluating what current land use is provides the baseline of what current conditions are. How that use changes over time (LUC) establishes how the landscape has evolved, with insight for the future. This was done for years 2000, 2005, 2010, and 2013.

Regional vegetation patterns (from the MODIS satellite) clearly show how focused vegetation is on the highlands. The patterns suggest that most of the eastern and northern parts of the highlands are open shrub-lands and cropland/natural vegetation mosaics. More purely croplands are present on the western slope. The Sana'a basin is at the transition, sloping from the more vegetated highlands down to the more barren lowlands (see Figure 4).

In addition, the more western part of the area has considerable rain-fed crops/natural vegetation. To the north/northwest is vegetation that is mostly *qat*[2] combined with irrigated mixed crops (local knowledge is important to distinguish between the two). To the central/east is more grape production, mixed further east with *qat*/mixed (see Figure 5).

The next question is how has this mix of vegetation evolved over time? To examine this question, a Landsat satellite image from March 3, 2003 was classified in the same way, and

[2] *Qat* is a mild stimulant leaf chewed for recreation.

the difference examined ("Land-use change"). Results, while highly preliminary, are intriguing. Overall, there is a quite substantial change in the land-use patterns. The extent of grapes appears to be less. Rain-fed crops may have increased, relative to grapes. The most pronounced change is an increase in *qat*/mixed irrigated agriculture (see Figure 6).

More refined image analysis is needed. However, the available data suggests that there has been a significant evolution in the landscape of the Sana'a basin over the last 11 years.

3.2.5. Regional Climatology (1948-2010)

The next issue was to examine patterns in the climatology of the region; that is, the rainfall (P), daily maximum temperature (Tmax), and daily minimum temperature (Tmin), covering the period 1948-2010. Over the period of record, precipitation showed pronounced phases. From 1948 to about 1970, annual rainfall was highly variable, with an average of 471 mm/year, with standard deviation of 247 mm/yr (see Figure 7). During high rainfall years, rainfall was in the 600-800 mm/yr range. From 1970 on, average rainfall decreased to 311 mm/yr, with a standard deviation of 98 mm/yr. High rainfall years would serve to replenish ground water reserves. Both minimum and maximum temperature showed a statistically significant increase over the period of record (see Figure 8). The combination of decreased rainfall and increased temperature adds further stress to the water cycle of the basin.

3.2.6. Changes in Total Water Storage

Closely related to rainfall patterns is the "change in total water storage" across the region. With information from the GRACE (Gravity Recovery and Climate Experiment) satellite, 2003-2013, clear seasonal patterns in storage were seen, corresponding to the precipitation regime. There has possibly been a gradual reduction in overall storage over the period of record (see Figure 9). Given the large errors associated with a very small signal, it is too early to make significant statements about these trends, but results are suggestive.

3.3. Analysis of the Socio-economic Context

Understanding how rural people have adapted to the bio-physical and socio-economic changes over time to reduce their vulnerability, thereby, enhancing their resilience required descriptive panel information for rural households both at the household and farm levels captured through household surveys. While this type of information is not readily available

for Yemen, this paper offers brief static descriptive background on communities in the rural Sana'a region. This was done using the 2005-2006 Yemen Household Budget Survey (HBS). As a second best approach and complementing this effort, qualitative description is provided of the communities in the rural Sana'a region in terms of how they adapted to the bio-physical and socio-economic pressure.

The aforementioned data constraints on lack of available up-to-date household survey information limits the establishment of linkages between changes in the biophysical environment and how the communities until the recent years have managed to adopt to these changes. As a result of this limitation, qualitative information has been used to provide an overall picture of the socio-economic changes over time. Currently a survey is being undertaken (Yemen Household Budget Survey 2013/2014) which is an update of the 2005/2006 HBS. There is potential to update the socio-economic assessment through future analyses after the survey data becomes available. Additional constraints which have limited establishment of linkages between the biophysical and socio-economic sections involved the lack of opportunity to undertake field work due to security concerns in Yemen.

3.3.1. Quantitative Analysis of Household Data

The quantitative analysis was purely descriptive. According to the 2005-2006 Yemen Household Budget Survey, the poverty incidence in the overall Sana'a region was 28% and nearly 10% were food insecure. Out of the 4,527 Yemeni households captured in the agriculture section of the HBS, nearly 68% rely on rain water as a source of irrigation, and 25% rely on wells for water. In the rural Sana'a region, 56% and 39% of the households in rural Sana'a region rely on rain and wells respectively for irrigating their lands. In addition, 91% of households in rain-fed rural Sana'a region engaged in livestock activities, and 15% have enterprises. As for the type of land ownership, 48% of rain-fed lands are owned, and 39% are share-cropped.

The majority of the household heads in rain-fed rural Sana'a region are illiterate (84%) and only 1% are female headed households, while the percentage of female headed households in the rain-fed areas in rural Yemen is 6%. Even though women are central agents in the rain-fed areas, estimates on percentage of female headed households may not reveal this fact, due to for example the definition that may have been used in the survey to classify a household member as a household head.

As for source of income during the past 12 months (of the survey year) in the rain-fed rural Sana'a region, *qat* production and sales is a primary mean of deriving agriculture income. According to the 2005-2006 HBS, income proceeds from the sale of *qat* averaged 193,503 Yemeni Riyals relative to sales from non-*qat* crops amounting to 10,366 Yemeni Riyals.

While income from *qat* sales contributed substantially to the overall household income, the households seemed to have also relied on alternative source of income for diversifying their livelihood strategies. According to the 2005-2006 HBS, on average households in the rural Sana'a region received 3,932 Yemeni riyals from their retirement payment income, 2160 riyals from the Social Welfare Fund, and 2,628 riyals from remittances. Remittance income is a vital source of livelihood support to households in rain-fed areas but the question remains about its sustainability with increased limitations of migration opportunities.

According to the 2005-2006 HBS, households in the rural rain-fed Sana'a region have obtained loans for several reasons. The most cited reason is borrowing to meet household's consumption needs and this was the response of 57% of the households, followed by borrowing for ceremonials such as weddings, funerals, etc… (28%) and 27% of the households cited borrowing to meet emergency needs. The sources of the loans are diverse but the majority of the rural rain-fed households in the Sana'a region (73%) borrowed from friends/neighbors.

Overall, while income from the sales of *qat* is the primary source of livelihood in the rain-fed communities of the rural Sana'a region, alternative sources of income as indicated are also important. However, given constraints in water availability for crop production including *qat* fiscal constraints, and limits on migration, the coping mechanisms for increasing resilience against bio-physical and socio-economic changes may not be sustainable potentially leaving rain-fed communities vulnerable.

3.3.2. Qualitative Analysis

As part of the socioeconomic assessment, the study included a qualitative assessment of the study sites (see Figure 2) identified within the broader study area (Figure 1). In this section, relevant findings are reported.

In the ***Bani Matar*** site, almond is recognized as a strategic crop. It is considered a drought tolerant cop and grows in areas low rainfall amounts (150-400 mm). However, during the

flowering and fruiting stage, water availability becomes crucial. Communities view this crop as a substitute for the *qat* production which is a promising source of income for farmers in Bani-Matar.

In the ***Bani Hushaish*** site, 35% of the cultivated area is used for grapes production, 30% for vegetables, and 35% for *qat* production. In this area, poor living standards of local people led many owners and users of wells to look for other income sources through selling water to others.

In the ***Bani Al-Hareth*** site, key crops produced include coffee, almond, and *qat*. The challenges facing this area include the wastewater and drainage system from the capital being directed to Bani Al-Hareth. Therefore, the community continues to face challenges from biological and chemical contamination, which can significantly affect rural landscape development.

The ***Manakhah*** site is famous for planting coffee as a valuable source of income. However, recently *qat* is grown as much as coffee is, and competes with vegetable crops as well. Land degradation is present in the terraced farms especially during the rainy season. Helping the farmers in adopting optimal land and water management practices will significantly raise income and reduce poverty.

In the ***Amran*** site, this area has the highest level of poverty in both rural and urban Amran. In Amran governorate, farming is the main source of income after livestock production. The governorate which is considered agriculturally fertile, meets a major share of the country's agricultural needs. Most farmers in the governorate practice subsistence farming of maize, wheat, millet and vegetables. However, the series of conflicts in the area in recent previous years had a severe impact on the agricultural sector. Farmers were hard hit as the agricultural cycle was interrupted, inflation soared, and public services deteriorated and became unreliable. With the aim of improving farming practices, the Yemeni government setup agricultural research farms in different parts of the country. In the Amran governorate, for example, an agriculture research station was set up to introduce improved varieties of grains and fruits, and to help local farmers adopt new technologies.

3.4. Analysis of the Institutional Context

3.4.1. Methodology for Institutional Analysis

This component of the study built on institutional mapping and assessment of governance capacity of rural organizations done in a 2007-2008 study on Mobilizing Rural Institutions for Development, which carried out case studies in Yemen, along with Afghanistan, Ethiopia, India and Vietnam. For this paper, review of project reports, articles, books, and other sources provided additional and updated information on rural institutions in Yemen. During April 2014, the authors conducted semi-structured interviews in Yemen with representatives from government agencies, development projects, universities, district councils, water user associations and other organizations. The interviews solicited information on experience and views on the roles of rural organizations and opportunities for enhancing the contribution of local institutions and organizations to rural development.

3.4.2. Key Findings on Institutions

We found that Yemen has strong traditions of consultation, cooperation, and mediation. Yemeni communities have a long history of deliberative decision-making based on extensive consultation among local people. The power of leaders, such as sheiks and judges, has depended heavily on support from below, respect for those able to solve problems and negotiate solutions, along with leaders' ability to provide money and other patronage. Farmers have worked together in many ways, for example cooperating to divert spate flows from streams, and channel springs and rainfall runoff to homes and fields. Conflicts have usually, but not always, been managed through customary practices for mediation and arbitration, often applying principles from customary law and Islamic scriptures to seek just and workable solutions. Agreements and associated dispute resolution institutions provide an enabling framework for business in rural areas, including agricultural value chains and non-farm businesses. Local institutions have included efforts to protect those who are vulnerable and provide charity for those in need. Changes, including centralized patronage and conflicts in recent years have challenged, and sometimes weakened customary relationships, but these still provide patterns for developing cooperation and coping with conflicts.

Secondly, in Yemen, community institutions govern local land and water. Local property rights, including rights to land and water, have largely been established and enforced in the context of local communities in Yemen, including rules, mediation, and adjudication based

on customary and Islamic law. Customary rights have created sufficient security to invest in improving fields, planting trees, building terraces, and making other investments that have reshaped rural landscapes. In a climate of limited and uncertain rainfall, water allocation rules can offer farmers clarity about how much water they might expect. Customary rules reserved pastures for times of scarcity, promoted regeneration of desirable forage, and combined protection of crops with post-harvest access for grazing. Property rights and local law and order based on community institutions enable people to grow crops, cooperate, engage in trade, make agreements, and resolve disputes. These institutions have been challenged by and have adapted to changing conditions over time, including periods of drought, warfare, population growth, expansion of roads and opportunities for commercial agriculture, and other changes. Those with links to political, economic, and military power have sometimes been able to use this to acquire more land, and control economic opportunities. However, despite inequities and abuses, the ways in which rural communities have coped in recent years indicates the continuing vigor of local capacity for self-organization.

Thirdly, local institutions are closely linked. Organizations at the local level include "tribal" social structures, district local councils, agricultural cooperatives, water user associations, and local charitable associations. Tribal relationships actually take many forms, from large federations to small local lineages, and, depending on circumstances, may be less important than other economic, political, religious relationships. Women's organizations and non-government organizations are active in some areas. District local councils, established by government, have elected members. District offices form the lowest formal level of government administration, and most districts have offices of some agencies, including education, health, and agricultural extension agents. Local charitable organizations may contribute to and be involved in the management of mosques, schools, and other services. The Yemen Women's Union has over 132 branches at the national, governorate, and district level.

Fourthly, organizations may be linked by flows of information, resources such as money, and influence or hierarchical control. The 2007-2008 study looked at relationships between local organizations in four governorates, concentrating on district local councils, "tribal" social structures, and agricultural cooperative societies. The study found much diversity between the four study areas. But, in general, local organizations were relatively well connected with each other, while links to external organizations and projects were sometimes weak.

Figure 10 shows network diagrams of linkages between district local councils and other organizations in the four study sites. In these diagrams, what matters are the patterns of connections, not the particular location in the diagram. Thus, it is important if organizations have many linkages or few, whether there are groups of organizations that are more closely linked in subgroups, or others that are relatively isolated. In general, the diagrams show that different local organizations are closely linked with each other, including links to local executive (administrative) offices and the Social Fund for Development (SFD). By contrast, there are often fewer or weaker linkages with outside organizations, including development projects, which sometimes have only indirect links with local organizations.

Fifthly, informal and "tribal" social structures have substantial governance capacity. Figure 11 compares inclusiveness, representativeness of leadership, accountability, participation, and adaptability. Social structures of local leaders, networked through primarily informal institutions, had relatively high governance capacity, agricultural cooperative societies usually had low capacity, and district local councils had some capacity. There were differences between areas, in particular DLCs were relatively stronger in Tuban in the south than in the other more northern sites. Review of more recent literature and interviews in 2014 confirmed the continued importance of informal organization. The protests and conflicts in 2011-2012 revealed, among other things, generational differences in views and aspirations, including frustration and dissatisfaction with the older generation of leaders. Generational differences are likely to pose continuing challenges, including in rural areas. Thus, substantial governance capacity does exist at local levels, which can contribute, within suitable arrangements, towards rural development.

Sixth, local organizations have helped implement projects. Many projects in Yemen have successfully supported establishment of groups, associations, and cooperatives that have contributed to project implementation. Some local organizations continue to provide services that generate revenue and are supported by local communities, such as associations for household water supply and some fisheries cooperatives. However experience has shown that, after projects end, organizations induced from above, including irrigators' organizations and agricultural cooperatives, often quickly become inactive, while project units and their personnel are disbanded. This loss of social capital shows a need for more sustainable approaches to institutional development.

Lastly, communities can plan and implement local improvements. Since 1997, the Social Fund for Development has carried out a participatory process of community-driven development (CDD), which is now active in all parts of Yemen (Al-Iryani et al, 2013). Local committees, formal and informal, are involved in identifying needs, setting priorities, preparing proposals, implementing activities, and carrying out operation and maintenance. The project has emphasized transparent and impartial administration, social inclusion, and capacity building for all those involved, including farmers, leaders, and contractors. IFAD and GIZ-funded projects have also demonstrated substantial achievements combining bottom-up participatory processes of planning and implementation with suitable support. SFD and other participatory projects have been affected by civil conflicts and other difficulties, but often have been able to maintain local support and continue operating despite difficult conditions. Lessons from these participatory projects, including achievements and limitations, progress and regress, can contribute to further improving inclusion, and equity in project processes and outcomes.

4. Conclusions

This paper focused on the constraints and opportunities for rural development in Yemen. We identified and studied three inter-related areas that underpin rural development in Yemen: the bio-physical environment, rural livelihood strategies, and rural institutions. The study used a GIS database as the source of information for assessing the bio-physical environement; quantitative household data and a qualitative field survey for assessing rural livelihood strategies; and a desk review and informational interviews for assessing the rural institutions.

The main contribution of this study is in the integration of these three pieces of analysis, which are rarely put together. Natural resources frequently serve as the basis of rural livelihoods, and therefore any studies of land, soils, and water should be combined with socio-economic studies of the rural populations dwelling near these resources. Conversely, rural livelihood strategies are usually determined by the availability of natural resources. That this is not frequently done is likely due to the lack of data at the appropriate scales in time and space. Our study faced the same limitation: the household data, institutional surveys, and GIS layers do not line up exactly along the lines delineated for our study. However, we believe this attempt at integration is still useful for drawing broad conclusions for policy and for setting an example for future analyses.

With regard to the main constraints, the abandonment of agricultural land is a phenomenon mostly driven by socio-economic factors such as immigration into areas where new economic opportunities are offered to rural people. Ecological drivers such as elevation and land mismanagement (biophysical factors) leading to soil erosion and reduced soil fertility are of secondary importance. However, water remains the central constraint for the development of agriculture in the study area. This conclusion matches that of similar studies from other regions (e.g. Cooper et al. (2008) report similar findings for countries in Sub-Saharan Africa) The existing constraints on water are further exacerbated by the expansion of *qat* and other irrigated crops, and migration of males from rural areas is threatening the existing coping mechanisms (such as terrace construction and maintenance).

Yemen's rural areas are poor, and rely on a vulnerable natural resource base. Over time the bio-physical environment has experienced increased temperatures and decreasing precipitation. At the same time, social changes in terms of population growth and migration have impacted the maintenance of the natural resource base for example, affecting traditional natural resource management practices that promoted sustainability of both land and water use.

However, by combining the above assessment with the socio-economic study and the institutional mapping study, we can draw at least one additional conclusion: Yemen has strong institutional capacity, which has been used for community-based management of water and land. This presents opportunities for addressing the major constraint identified in this study (water scarcity) through policies that recognize and take advantage of the community processes for managing natural resources.

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Table

Table 1. Yemen Rural Institutional Linkages SWOT

Strengths	Weaknesses and constraints
• Traditions of consultation, deliberative decision-making, and cooperation • Community-backed land and water rights • Adaptive capacity and resilience of local self-organizing institutions • Dispute resolution mechanisms • Social, business, and political relationships link rural & urban people • Social capital of existing business value chains • Local knowledge • Protection and charity for socially vulnerable	• District local councils (DLCs) and local administrative offices well-linked locally, but lack capacity and resources • Social inequities and less involvement of women, youth, poor, socially marginalized • Vulnerability to elite capture of benefits, and elite escape from local accountability • Limited access to relevant knowledge about markets, technology, finance, etc. • Post-project loss of social capital of organizations and relationships
Opportunities	**Threats and Risks**
• Combining external assistance with local (decentralized) capacity for problem-solving • Flow of remittances: improving use of funds and financial links • Improving and diversifying value chains: sorting, packaging, branding, certification, etc. • Migration: benefiting from contacts, information, coping options • Information technologies: cellphones, internet, SMS, etc.	• Centralized interventions may discourage (crowd out) local initiative and capacity • Cronyism and corruption • Violence disrupts social relationships, destroys trust, dislocates people • Losing access to water and land resources, due to resource degradation, depletion, and capture; climate change, conflict, and other problems • Youth lack links to get jobs, lack opportunities and incentives for constructive involvement

Figures

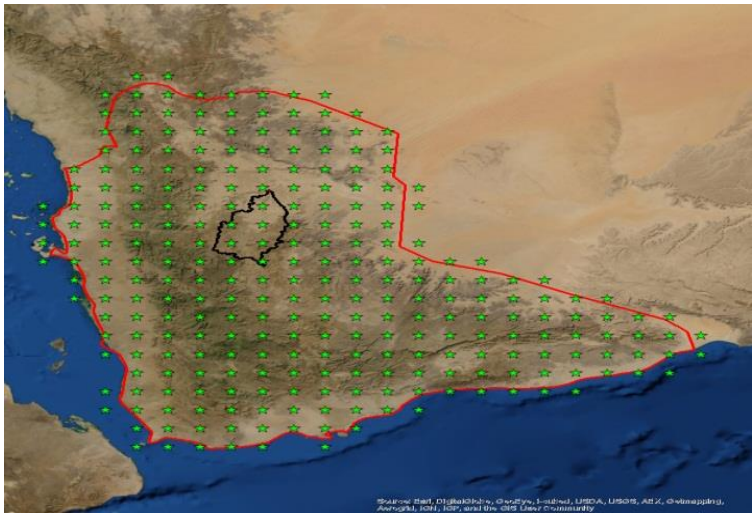


Figure 1: Delineation of the regional scale (western Yemen), in red line. The Sana'a basin is shown, in black outline

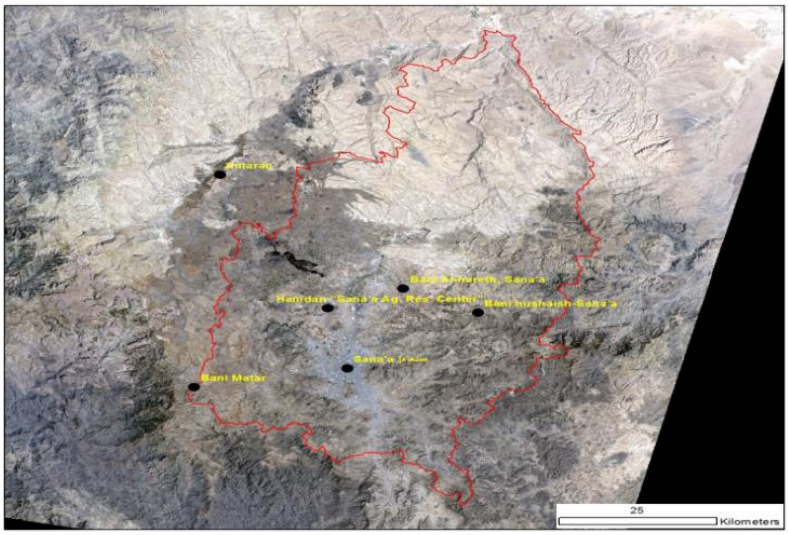


Figure 2: Image of the 6 study sites

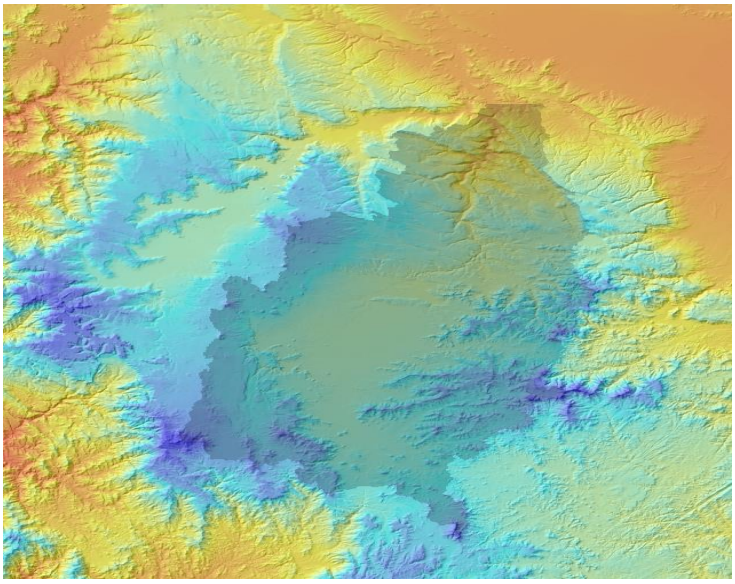


Figure 3: Topography of Sana'a basin

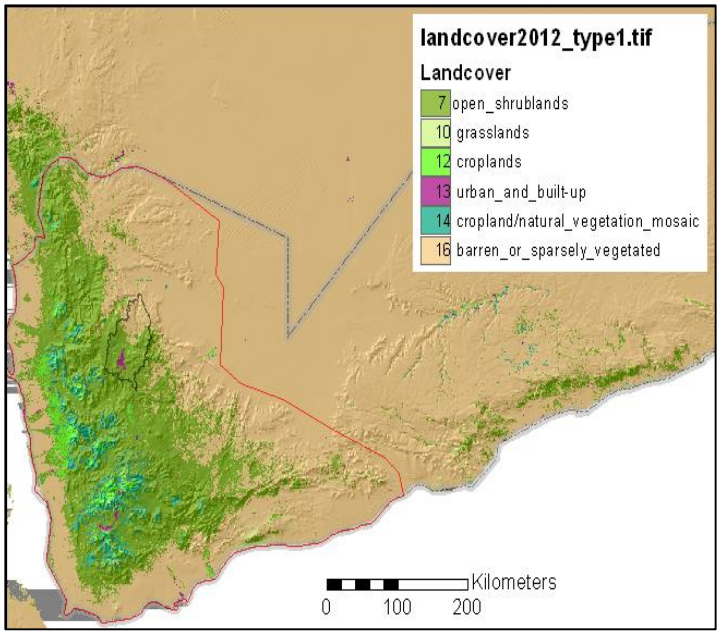


Figure 4: Land cover classes for Western region and Sana'a basin

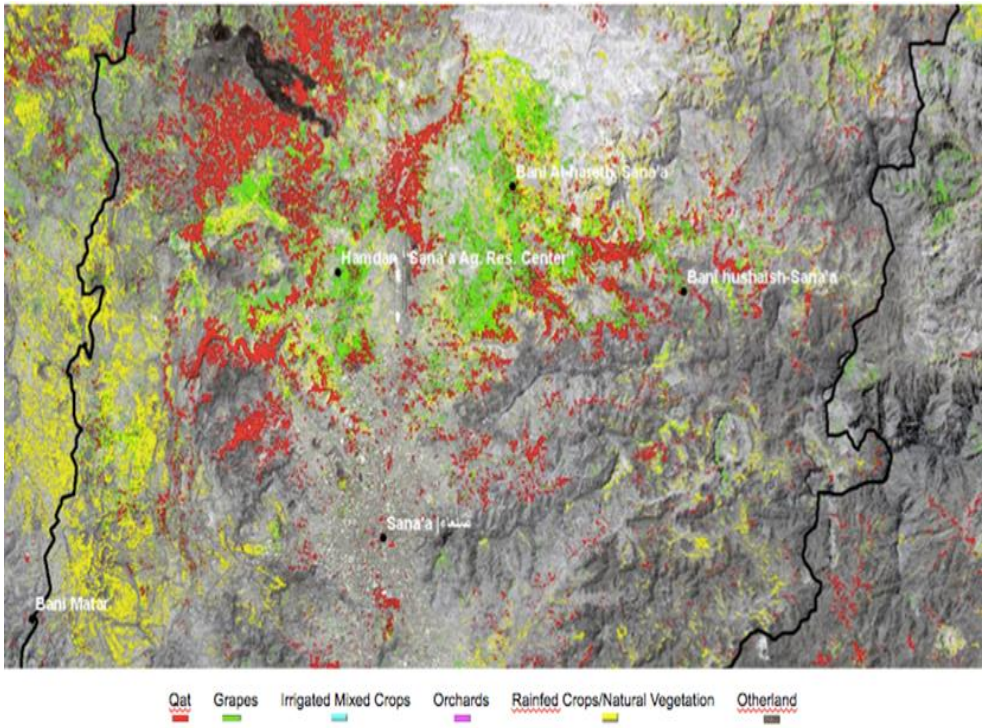


Figure 5: Preliminary vegetation classification in the 6 study sites

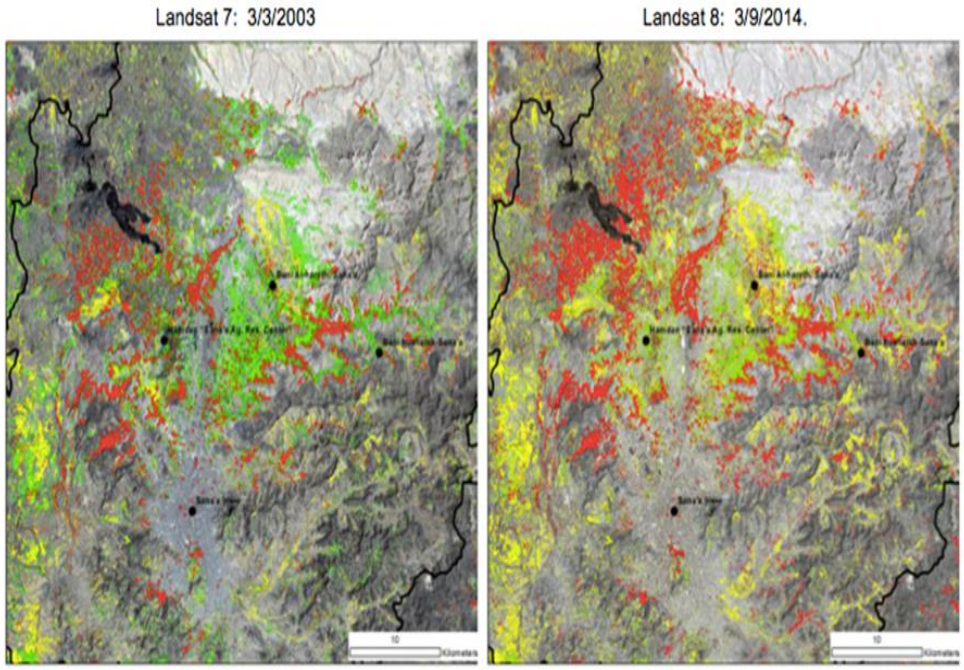


Figure 6: Land-use change in the 6 study sites

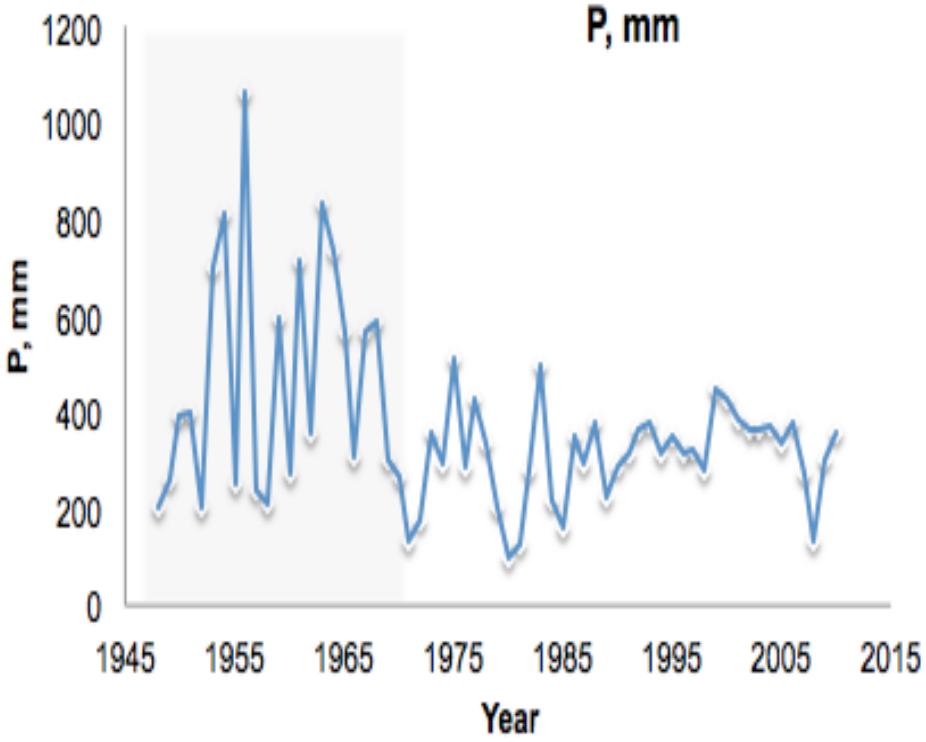


Figure 7: Mean yearly records (1945-2015)

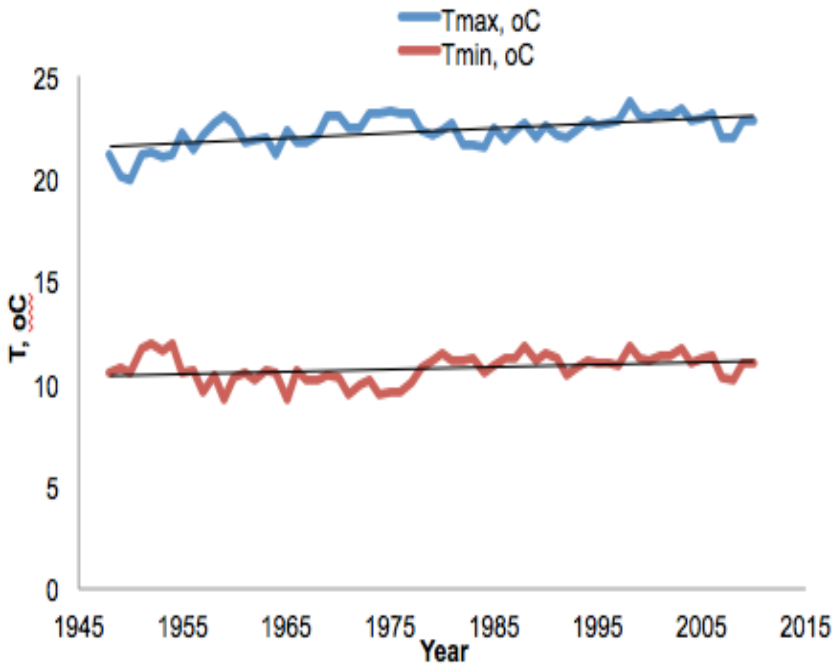


Figure 8: Mean yearly minimum and maximum temperatures

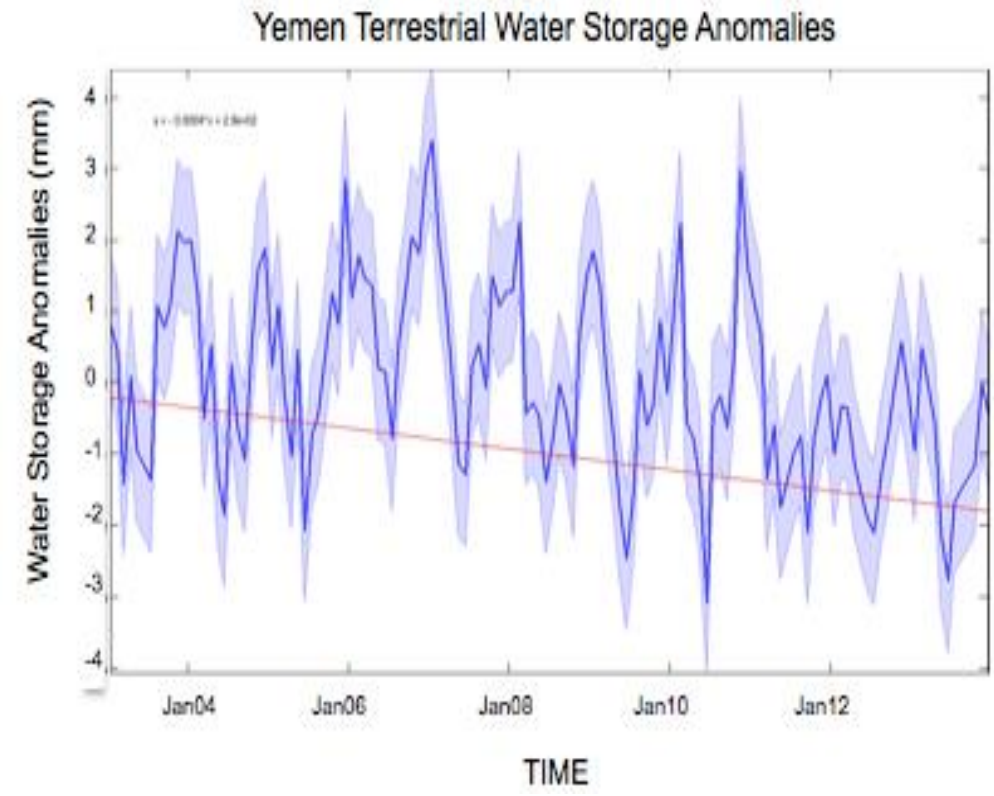


Figure 9: Terrestrial Water Storage

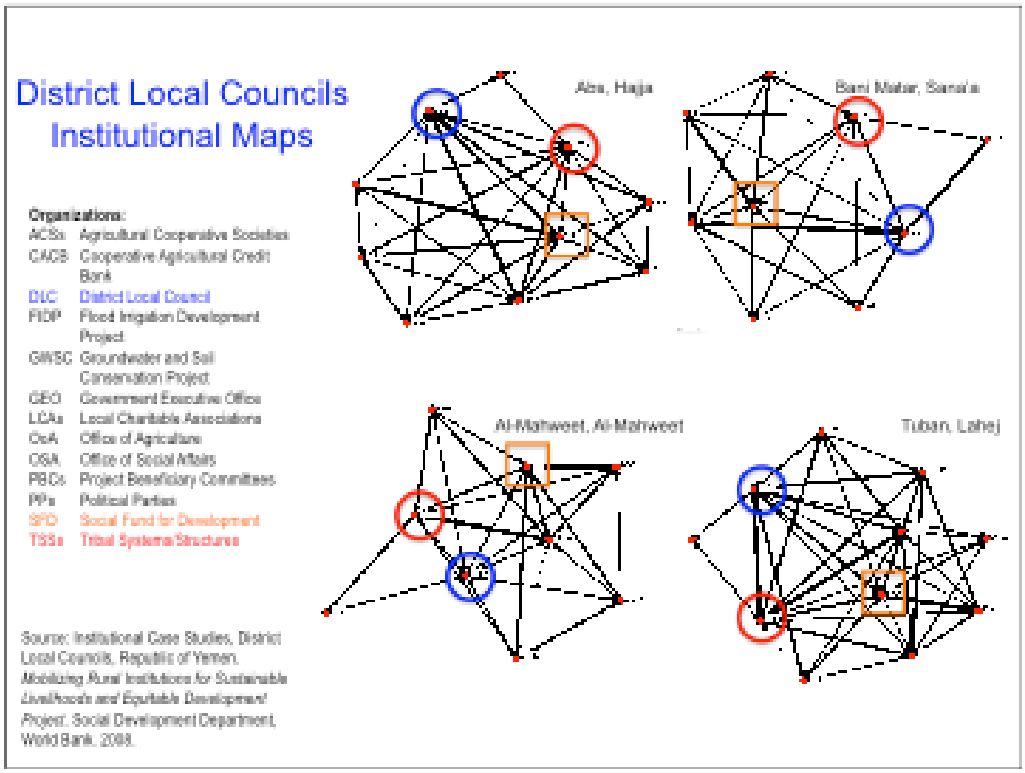
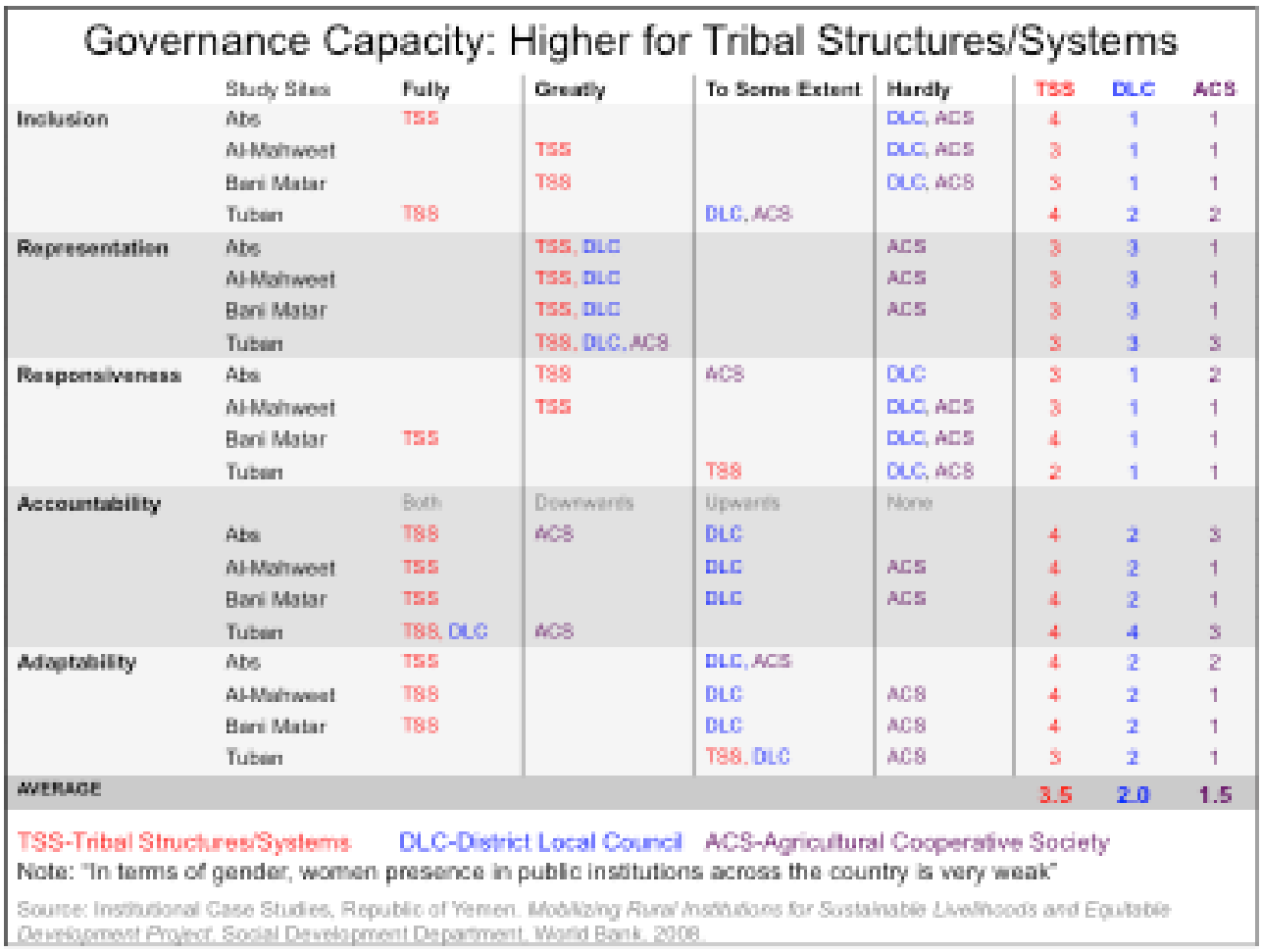


Figure 10. Institutional Linkages for District Local Councils



Governance Capacity: Higher for Tribal Structures/Systems

	Study Sites	Fully	Greatly	To Some Extent	Hardly	TSS	DLC	ACS
Inclusion	Abs	TSS			DLC, ACS	4	1	1
	Al-Mahweet		TSS		DLC, ACS	3	1	1
	Bani Matar		TSS		DLC, ACS	3	1	1
	Tuban	TSS		DLC, ACS		4	2	2
Representation	Abs		TSS, DLC		ACS	3	3	1
	Al-Mahweet		TSS, DLC		ACS	3	3	1
	Bani Matar		TSS, DLC		ACS	3	3	1
	Tuban		TSS, DLC, ACS			3	3	3
Responsiveness	Abs		TSS	ACS	DLC	3	1	2
	Al-Mahweet		TSS		DLC, ACS	3	1	1
	Bani Matar	TSS			DLC, ACS	4	1	1
	Tuban			TSS	DLC, ACS	2	1	1
Accountability		Both	Downwards	Upwards	None			
	Abs	TSS	ACS	DLC		4	2	3
	Al-Mahweet	TSS		DLC	ACS	4	2	1
	Bani Matar	TSS		DLC	ACS	4	2	1
	Tuban	TSS, DLC	ACS			4	4	3
Adaptability	Abs	TSS		DLC, ACS		4	2	2
	Al-Mahweet	TSS		DLC	ACS	4	2	1
	Bani Matar	TSS		DLC	ACS	4	2	1
	Tuban			TSS, DLC	ACS	3	2	1
AVERAGE						3.5	2.0	1.5

TSS-Tribal Structures/Systems DLC-District Local Council ACS-Agricultural Cooperative Society

Note: "In terms of gender, women presence in public institutions across the country is very weak"

Source: Institutional Case Studies, Republic of Yemen, *Mobilizing Rural Institutions for Sustainable Livelihoods and Equitable Development Project*, Social Development Department, World Bank, 2008

Figure 11. Governance Capacity Assessment