VISUALISING THE LANDSCAPE:

Spatial Analysis of Forest Ecosystem Services for Socially Differentiated Groups in Orissa, India.

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Summary

Maps are powerful, conveying visual images of the landscape and revealing patterns. Often less accessible to local people, the integration of participatory rural appraisal techniques with GIS provides a promising tool, which can provide a more complex but realistic understanding of landscapes and the people who are an integral component within them. PGIS compliments mixed methodologies and multidisciplinary enquiries and provides a holistic approach to demonstrate the complexity of socio-ecological systems, which are dynamic and multidimensional. This study uses this technique to reveal spatial patterns in a forest area in Orissa, India. This involves the spatial analysis of cultural and provisioning ecosystem services and reveals spatial patterns of socially differentiated groups across the landscape, which has been shaped by historical, social and cultural factors within the local and wider context. The analysis shows the changing nature social and physical boundaries in forest common property regimes, which new institutions, designed on mainstream collective actions models attempt to fix, facilitating exclusion of some social groups and better livelihood security for others. Through this analysis of these socio-ecological interactions the importance and social processes in influencing spatial dynamics for differentiated social groups is highlighted.

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Abbreviations:

DHG - Dhengjhari

JAG/ JAGG – Jagannath Prasad

LUN - Lunisihi

MAD - Madrakota

ST – Scheduled Tribe

SC – scheduled Caste

Gen- General Caste

JFM – Joint Forest Management

PGIS – Participatory Geographical Information Systems

GIS – Geographical Information System

UTM – Universal Time Meridian

WGS – World Geodatic System

GPS – Global Positioning System

CHAPTER ONE: Introduction

India is a vast and diverse land which is in the midst of rapid economic development focused on urban industrial growth (Deb, 2009). Some efforts have been made to alleviate poverty through this increasing economic growth but there are still large concentrations in rural areas (Mehta, 2003). In such a diverse landscape with wide ethnic and ecological variations across and within States, it is dangerous to over generalise. Nonetheless, the social structure across most of India is primarily hierarchical and patriarchal (Desia and Krishnaraj, 2004) and based on the caste system which ranks and socially defines groups recruited by birth. This grouping dictates behaviours, expectations, obligations and determines access, values, status and activities within society. Although some social mobility is possible as a group, individual identify in this respect is fixed (Cohn, 1971). Gender inequality is also prevalent throughout much of society, cutting across many social groups (Gupte, 2004). These gender dimensions are closely linked to the caste system, which not only determines social division of labour but also a sexual division to labour (Liddle and Joshi, 1986). Within this hierarchical system women are viewed as a gateway through the caste system and, as a result, the higher the caste the more segregated and removed from public spaces women become (Desia and Krishnaraj, 2004). Tribal society is predominantly not hierarchical in this manner, with women experiencing a much more equal position in these societies, although some cross fertilisation has been observed with an increase in gender inequality amongst some of these groups (Mitra, 2008). Gender relations are multidimensional with gender inequality being less pronounced in the lower caste households where survival depends more on effective co-operation (Dreze and Sen, 2004). The administrative label of scheduled caste (SC) and scheduled tribe (ST) was introduced by the State to help reduce the marginalisation of both these large and diverse social groups however, the socio-cultural landscape relating to gender, caste and ethnicity is deep seeded and interrelated, particularly in rural areas.

Orissa State, in the East of India is one of the poorest States, with 47% of the population classed as poor in 1999-2000 (Mehta, 2003). It also has a high proportion of scheduled caste and scheduled tribe populations, which is closely related to poverty in rural areas (Gang et al, 2008). Orissa has an approximate forest cover of 30% which includes moist deciduous, tropical dry deciduous, tropical semi evergreen and sub tropical broad-leaved hill forest (Conroy et al, 2002, Nayak and Berkes, 2008) This contains two main administrative forest categories: Reserve forest controlled and managed by the Forest Department and protected forest in or close to revenue villages with shared responsibilities between the

Forest Department and the Revenue Department (Singh et al, n.d.). The State of Orissa also contains the highest concentration of forest dependent populations, with particular dependence found in the tribal populations (Sarap, 2007). In response to declining forest based livelihoods there is a high number of self initiated community forest protection groups (CF) in the State (Chatterji, 2001, Ostwald and Baral, 2000 and Conroy et al, 2002) and more recently communities under Joint Forestry Management (JFM) which is a State led forestry co-management programme.

Forest common pool resources in Orissa therefore play and essential role in sustaining people in rural areas (Beck, 2001). Despite a long history of state control over these important resources, the Government has begun initiating a more people focused forest policy in the form of joint management between the State and local communities. However in Orissa, with a high number of existing community protection initiates, with a huge diversity within and between communities and a long history of forest dependence, this has not always been hailed as a success with critiques arguing, amongst other things, for greater emphasis of gender inequality (Gupte, 2004, Agarwal, 200,Cornwall 2003, Agarwal, 1992). Many highlight the need for attention to local context, including socio-ecological processes and recognition of existing systems without which may result in undesirable consequences when institutions are shaped around a simplistic 'one size fits all' model, particularly for socially marginalised groups (Conroy et al, 2002, Saito-Jensen and Jensen, 2010, Matta and Alavalapati, 2006, Chatterji, 2001) by increasing asymmetric distribution of benefits.

To facilitate a reduction in inequality it is important to develop effective ways of demonstrating and communicating these complex socio-ecological systems in a manageable manner which accounts for the multiple influencing factors. This study will analyse a particular case study from the Pathargonda Forest in Ranpur Block, Nayagar District of Orissa where there is a history of local protection, new JFM structures and a diverse local population who interact and utilise the forest. GIS (Geographical Information Systems) is used to analysis the spatial dimensions of the complex socio-ecological interactions of differentiated social groups with the forest landscape. The following chapter will introduce some of the literature related to this diverse area, after which a conceptual framework will be introduced that incorporates aspects from the mainstream collective action approach to common pool resources as well as aspects of the entitlements approach. This analysis therefore emphasizes the importance of local context in understanding these complex systems. GIS is used to spatially analyse the flow of provisioning and cultural services to gender and caste/ ethnically specific groups. The inclusion of forest based cultural services helps to emphasize the dynamic relationship of social processes in the flow and distribution

of these services within the local and wider context. Lastly, the merits of spatial analysis to demonstrate the complexities of these socio-ecological systems is assessed for future use.

Chapter 2: Review of literature

2.1 Recognising the Importance and Complexity of Common Pool Resources

Hardin's (1968) model of 'The Tragedy of the Commons' declared that self interest in unregulated state systems would inevitably lead to a degradation of these natural resource. This stimulated a wide amount of research into how these systems operate and succeed. A large body of this focused on forest systems which play a central role in many livelihoods of a diverse range of actors at multiple scales (Agrawal, 2007). It soon became evident that communities had been traditionally managing these resources to maintain livelihoods but also that these were complex socio-ecological systems which are influenced by a wide range of factors (Pierce-Colfer, 2005). Two schools of research have emerged in common pool resource research, taking very different approaches to the study of these essential socio-ecological systems. With these systems being particular relevant in attaining poverty alleviation objectives, which are high on the international agenda, an examination of the merits of these two approaches is pertinent (Johnson, 2004). The first approach developed a common property theory based on models and economic concepts with efforts to establish general principles and rules to provide a more efficient path for governance (Ostrom, 1990, Dolsak and Ostrom, 2003, Agrawal, 2002). A theory of common property emerged relating to how these systems could be regulated to enhance efficiency through collective action. Further categorisation emerged alongside the term 'open access', which referred to systems under state control where local people had little incentive for sustainable action due to the states control and appropriation of these valuable resources. This included the often confused terms of 'common property regimes' and 'common pool resources'. The former is used to refer to the rules, duties and rights which evolve between individuals to maintain the flow of benefits. The term common pool resources however concerns the actual systems which are large and complex, thus making it difficult to prevent individuals from using them (Johnson, 2004). Common property theory primarily focuses on the role of formal institutions to manage stocks and flows of benefit (Agrawal, 2003) with an underlying principle that general rules exist to facilitate the flow of this capital for the larger benefit. However, critics of this mainstream approach emerged suggesting that an apolitical and ahistorical method was inadequate in teasing out the finer, often contextual factors, with the need to recognise processes and not just outcomes relating to material interests (Mosse, 1997, Goldman, 1997, Johnson, 2004).

The second school which emerged to challenge Hardin (1968) had its roots in notions of the moral economy (Johnson, 2004). In contrast to the collective action approach the entitlements approach distinguishes between the endowments social actors have and their entitlements. Endowments are 'the rights and resources which social actors have' and entitlements are the 'sets of utilities derived from environmental goods and services over which social actors have legitimate effective command' (Leach et al, 1999 p.233). This brings into focus how actors access resources and the various mechanisms by which they achieve this. This includes formal rights but also negotiation with formal right holders in addition to the ability to transform these goods to positively contribute to their wellbeing through institutions such as markets (Ribot, 1998). The entitlements school analyses processes which influence the use of resources by social actors, with particular emphasis on poor and vulnerable groups, thus placing them in a more centrally in the analysis. The entitlements approach therefore provides additional signposting for progressing poverty alleviation objectives and highlights that securing formal rights to collect forest goods is only one of a number of important considerations and a sole focus on this would not guarantee a reduction in poverty (Ribot and Peluso, 2003, Leach, Mearns and Scoones, 1999, Peluso, 1996, Sikor, 2007).

Collective action has influenced policy development through decentralisation programmes around the developing world by providing a simplistic model with clear design criteria. The entitlements approach however, analyses through a political ecology lens to demonstrate the finer nuisances which affect these systems with an emphasis on local and historical context and the need for deeper understanding of the complexity, uncertainty and dynamics that underlie social and ecological processes (Johnson, 2004).

The role of community based management of natural resource systems has thus been thrust into centre stage with a plethora of donor driven initiatives to recognise and re-establish this traditional system of governance. Governments across the developing world have seized the opportunity to harness this enthusiasm and provide more cost effective management in common pool resource systems where conflict between the state and local communities often erupted (Peluso, 1996, Johnson, 2004 and Mosse, 1997). One of the earliest initiatives was in India, which took the form of Joint Forestry Management (JFM) and was first introduced in 1990 (Saito- Jensen and Jensen, 2010) following a move away from forest management for commercial timber towards a more people centred, partnership approach (Gupte, 2004). Although successful in many locations, local variations in its success began to be highlighted across India indicating that a 'one size' did not fit all (Saito-Jensen and Jensen, 2010, Gupte, 2004, Nayak and Frikret 2008, Conroy et al, 2002).

Critiques regarding universal principles for common property institutions generally, and specifically relating to community based forest management in India, raise a number of ambiguities relating to variations in the role of group size, heterogeneity and powerful groups (Balooni et al, 2010, Baland and Platteau 1999, Agrawal 2003), gender inequalities (Chatteriji, 2001, Gupte, 2004, Agarwal, 2001, Cornwall, 2003) and the need to recognise that formal institutions are shaped by social life and culture (Cleaver, 2002). This emphasized the inadequacies of a universal model to predict success in these dynamic and complex socio-ecological systems (Mosse,1997). There are some small areas of common ground between the two approaches (Agrawal, 2003) however, there is still a large amount of what Johnson (2004) calls 'uncommon ground', particularly in filtering through to policy (Cleaver, 2002 and Mosse, 1997).

The inadequacy of 'community' as the smallest unit of management was highlighted by Agrawal (1999) who stressed that the 'community' as a small, homogenous unit with shared values and beliefs more often than not is a myth. This approach, although administratively simple for community management initiatives, often ignores social sub groups, multi-dimensional identities(Cleaver, 2002 and Rocheleau and Edmunds, 1997), relational networks which link villages, households and individuals together and within the dynamics of the ecosystem (Folke, 2007). The role of gender (Rocheleau and Edmunds, 1997, Cornwall, 2003, Ostwald and Baral, Gupte, 2004), poverty (Sikor, 2007, Conroy, 2002) caste and ethnicity (Ostwald and Baral, 2000), social networks (Cleaver 2010, Bodin and Crona, 2009), power dynamics (Balooni et al, 2010) and their interlinking nature have been emphasized as important factors for consideration. Social relations and identifies extend between and within communities but are influenced by the dynamics within the wider and local context (Chatteriji, 2001,Cleaver, 2002). Over simplifying the human landscape could have unintended consequences for particular sub groups (Saito-Jensen and Jensen, 2010) and weaken the overall system. Local groups connected through social processes to the landscape, as highlighted in coevolution (Gual and Norgaard, 2010) and adaptive governance literature (Folke, 2007), constitute a fluid process involving multiple identities and relations. Thus, demonstrating non linear social and ecological relationships and feedbacks (Folkes, 2007), which are enacted via conscious and unconscious decision and actions (Cleaver, 2002).

These debates, and the recognition of important historical and socio-political factors which remain out of focus in the mainstream common property theory approach, has lead some to suggest that efforts should be made to align the collective action and entitlements approach to build on the strengths of each. However, the different roots from which each approach has emerged may present challenges, with variations in the language and methods used

(Johnson, 2004). The role of actors and social processes in these systems however is coming more and more into focus (Cleaver, 2002, Mosse, 1997 and Bodin and Crona, 2009). Although the other components are also important, such ecological state and outcomes (Folke, 2007, Agrawal, 2007), there is a strong evidence that social processes should occupy a more central place in mainstream common pool resource models and policy design (Johnson, 2004 and Cleaver, 2010 and Mosse, 1997).

The focus on common pool resources clearly highlighted and established in the mainstream the important role of these socio-ecological systems (Folke, 2007). As research surrounding forest common pool resources has snow-balled (Agrawal, 2007) the importance of local context, cross scale analysis, the role informal institutions in shaping formal institutions, the importance of process as well as outcomes and selection of an appropriate scale are all apparent (Weiland and Dedeurwaerdere, 2010).

2.2 Ecosystem Goods and Services

In 2005 the Millennium Ecosystem Assessment (MA) was published with the aim of raising the profile and visibility of the links between ecosystems and human wellbeing (MA, 2005). The resulting framework was designed around a stocks and flow model with the intention of encouraging greater visibility of the benefits to human wellbeing from ecosystems in policy development In keeping with this principle there was a strong emphasis on the economic valuation of the benefits humans derive from ecosystems and the recognition of multiple scales across time and space. The MA (2005) defined an ecosystem as ‘a dynamic complex of plant, animal and micro-organism communities and the non living environment interacting as a functional unit’ (MA, 2005). Although suggesting an enclosed unit, these systems in reality do not have clearly defined boundaries with frequent overlap within and transitional zones between these ‘units’. Ecosystem services are the links which provide benefit for human wellbeing. The main benefits were classified into four categories. The first, provisioning services includes services which provide food, timber, water and fibre. Regulating services are aspects of the natural environment which regulate our climate, floods, disease, waste and water quality. Cultural services provide recreational, aesthetic and spiritual benefits whereas supporting services ensure the health and sustainability of the system by providing services such as soil formation, photosynthesis and nutrient cycling (MA, 2005). This includes direct and indirect services, processes and outcomes. Provisioning services represent the collect of ecosystem goods, which has often been the focus for studies across temporal and spatial scales. However, the primary focus has been from a

biophysical and valuation assessment, with less attention to the embedded social process which facilitates these (Cowling et al, 2008). The Ecosystem services framework provides a lens to focus on the centrality of humans within these systems, which is further emphasised within the cultural services category. This includes people not only being an end user of services but as a component of an interrelated, non linear system where values and interests shape the landscape through social processes. There have been calls for a landscape approach to integrate the broad range of social and ecological variables to help understand the relationships between poverty in the landscape (Pijanowski et al, 2010). This has the potential to provide a more holistic approach to studying these complex systems and was applied by Raymond et al (2009) using GIS to map community values across all ecosystem service categories.

Critiques of the Ecosystem Services Framework include a concerns the popularity of this framework and its simplicity, which ironically was the aim of the assessment. From a research perspective, its huge popularity comes with a wide variety of interpretations which can result in implementation through an overly simplistic perspective which overlooks the complexity of these systems in the rush to jump on the band wagon (Norgaard, 2010). The real risk with this therefore is to fall into a trap of producing mis-informed policy which does not adequately address the underlying issues. In a similar vain to the entitlements school in common pool resource research, the importance to disaggregate the human aspect of the framework to recognise differentiated social groups and differentiated outcomes is also starting to emerge (Brown et al, 2008).

Debates also encompass the categories used in the framework to classify ecosystem services in being narrow and mixing processes and outcomes (Wallace, 2007). However, as Costanza (2008) highlights, any framework is, by nature, a gross oversimplification of reality and in fact multiple classification systems are needed to represent the vast array of different perceptions, interests, values and scales which contribute to the complexity of these multidimensional systems (Pierce Colfer, 2005). The ecosystem services framework adds to the tool box to help demonstrate how ecosystems benefit people (Costanza, 2006). Even so, it is essential not to loose sight of the scientific knowledge which provided the foundation for this framework (Norgaard, 2010) - socio-ecological systems are dynamic, complex, non linear and include multiple links and feedbacks.

2.3 Ecosystem Services and Poverty Alleviation (ESPA) programme

The potential to apply the Ecosystem Services framework to poverty alleviation objectives was clear and the Ecosystems Services and Poverty Alleviation (ESPA) programme was initiated. This provided an assessment of opportunities and gaps in applying this framework to meet poverty alleviation objectives across different geographic regions, including South Asia (ESPASSA, 2008). This includes the need for improved spatial information on poverty and landscape domains, particularly relating to livelihoods. Once again, there was an emphasis on recognising that poverty is multidimensional and situational relating to individual and household identities as well as endowments (ESPASSA, 2008).

This report advocates the use of spatial analysis tools such a GIS to help fill this gap, and highlighted some of the few previous attempts to apply this tool in this context. This includes a study by Erenstien et al (2010) across northern India, which spatially analysed livelihood assets and poverty rates. Macro and meso scale analyses are vital to help influence national decision makers however Erenstein et al (2010) cautioned that at this scale data accuracy, availability and integration are significant challenges and coarse resolution outputs are therefore inevitable. The consequences of this include the potential masking of important factors in the spatial relationship between poverty and ecosystems for particular social groups (Erenstein et al, 2007).

2.4 Spatial mapping

GIS can be defined in a number of ways, however principally it consist of a computer system which includes hardware and specific spatial software with associated procedures for use. This enables the user to spatially reference, manipulate and analysis data to produce statistical and visualize spatial patterns across scales (Heywood, 2006). GIS enables data from different sources to be merged and spatially defined using common geographic references based on the earth's surface (Steinberg and Steinberg, 2006 and Kilskey, 1995). User capability and data accessibility and quality are essential elements in the effective application of this tool. Promisingly though, the capability of the software and accessibility to a wider audience is constantly evolving. The ability to create and use geographic visualisations in the form of maps provides a platform for communicating spatial knowledge (Dodge et al, 2008).

Nonetheless, map creation and use is steeped in power dynamics (Peluso, 1995, Parker, 2006, Pavlovskaya, 2006, Elwood, 2010, Robbins, 2003), which should not be ignored. Historically maps have been used by States in territorialisation, privatisation, integration and indigenization strategies (Hodgson and Schroeder, 2002 and Peluso, 1995), resulting in anger and mistrust (Janowski, 2009). Maps are simplistic representations of reality and what is and what isn't included often has implications for those on the ground (Robbins, 2003). How land is categorised and boundaries depicted is often of paramount importance as selected information is highlighted and other elements of real life is overshadowed. The emergence of counter mapping, a term coined by Peluso (1995) provided a technique to apply this tool to counteract mis-representative maps which often ignored local people and their claims to ecosystem services. From this the technique Participatory GIS (PGIS) emerged, which embodied the notion of greater participation in the creation and use of digital maps by a wider range of stakeholders (Janowski, 2009). This techniques draws upon participatory rural appraisal (PRA) techniques, which ballooned in popularity in community development programmes during the 1990's. The advantages of these techniques, which include facilitating community members to create sketch maps to show locally important landscape features, were clearly evident in applying more accurate visual representations of the landscape (Chambers, 1994). Whereas GIS has been applied extensively in natural resource management by technical experts (de Winaar et al 2007 and Swetnam et al 2011), particularly for conflict resolution objectives (Kwaku Kyem, 2001), the development of PGIS techniques opened up pathways for more stakeholder engagement in the process (McCall and Minang, 2005, De Freitas and Tagliani, 2009). However, with the involvement with more groups, power dynamics also can be further entwined in the process and participation and representation still requires attention with claims relating to participation not always resulting in empowerment and change (McCall and Minang, 2005, Heinimann et al, 2003).

Arguably the most powerful aspect of GIS is providing a platform for geo visualisation of relationships across the landscape, particularly when integrated with other tools such as Google Earth (Dodge,2008, Lefer et al, 2008), and Geographic Positioning Systems (GPS) (Bauer, 2006). This can enhance the accuracy, precision with higher scales possible for improved spatial analysis and legitimacy of the outputs (Peluso, 1995). Google Earth simulates the landscape from a variety of angles which may provide a better alignment with local people's perspectives of the landscape than to aerial views or topographic maps (Flavelle, 2002).

The integration of GIS with participatory techniques has the potential to provide greater legitimacy and power in this knowledge creation to corroborate and situate local knowledge

within the real world. Despite the caution surrounding the power dynamics relating to maps, the power of PGIS should not be ignored (Hodgson and Schroeder, 2002).

Although providing a sophisticated visual platform and associated analytical tools, much of the time two dimensional maps are still the outcome. These can provide a helpful visual record and demonstration of the complex use of space but, they still only represent specific views and specific features often of a specific time. This is only a snapshot of the landscape and this, should be regarded and applied as such. The PGIS process has also been criticised for fixing previously fluid processes, the flexibility of which are important elements in socio-ecological systems to learn and adapt as the local and wider context evolves (Elwood, 2010) and creating false boundaries which do not translate in reality. This includes both ecosystem boundaries (MA, 2005) and social boundaries, which may be fuzzy in nature with significant overlap over time and space (McCall, 2006). Important questions must be examined when applying this technique relating to who is being represented, how is knowledge generated and communicated, by whom and for what purpose (Rambaldi et al, 2006, Elwood, 2010).

Nonetheless, critical geographers highlight the vast potential and multiple applications of GIS and advocate a more positive approach to move away from its roots of purely quantitative data and association with modernism and colonialism (Elwood, 2010). Indeed, its ability to provide a holistic picture of a landscape and integrate qualitative and quantitative data (Pavlovskaya, 2006, Elwood, 2006) from scientific and locally based knowledge is of huge benefit to clearly demonstrate multiple spatial patterns and links between and within traditional disciplines. In addition to its application with political ecology, for example to examine the socio-political dynamics of physical boundary making in ecosystems in Tibet (Baure, 2006) its versatility and ability to integrate images and text to highlight myths and local perspectives of the landscape provides huge potential for future use, which is now slowly being realised (Elwood, 2010). However, care must still be applied throughout the process to avoid unintended consequences and not raise expectations (Rambaldi et al, 2006). Clear communicate of the limitations within the context it is being applied is essential but creative use to resituate the GIS as a tool away from its quantitative, elitist roots should also be encouraged.

Despite calls from critical and feminist geographers (Elwood, 2010, Rocheleau et al, 1994) and declarations by political ecologists of the importance of disaggregating below the community unit to examine socially differentiated social groups (Agrawal, 1999, Peluso,1996) spatial analysis at this scale to demonstrate the complex dynamics within socio-ecological

systems is not commonly applied. Saito- Jensen and Jensen (2010) demonstrated how the establishment of JFM (Joint Forest Management) in India resulted in differential impacts within and between communities with some groups being overlooked and excluded. This facilitated an asymmetric distribution of ecosystem service flows and caused in new conflicts with relating to social and physical boundaries as they were altered and traditional patterns ignored. Nevertheless, this study only applied GIS to highlight community boundaries and did not disaggregate ecosystem services or social sub groups within this spatial analysis. In addition, Rocheleau and Edmunds (1997) used sketch maps at different local scales to highlight the gendered nature of resource use and space, although once again, GIS was not applied with the participatory techniques they used to demonstrate the overlapping nature of these spatial domains.

When analyses have disaggregated social groups the unit of analysis has predominately been livelihood categories, for example herders and pastoralists examined by Robbins (2003) and Bauer (2006), hunter gathers (Hamilton et al, 2007) and fishers (De Freitas and Tagliani, 2009). Although poverty has individual characteristics (ESPASSA, 2008), there is poor take up of the use of PGIS at a local level to reveal the spatial dynamics associated with class, gender and caste. Identities are multi dimensional, crossing social groups. Feminist scholars highlight the importance of avoiding not only gender blindness, but also what Cornwall (2003) calls 'gender blinkedness' which over generalises and overlooks the socio-economic, differences, such as caste and class, between women, which result in huge variation in how they experience gender (Agarwal, 1992). The interrelated nature of these identities is clearly described in feminist analyses of gender relations in India (Desia and Krishnaraj, 2004, Nayak and Fikert, 2008, Liddle and Joshi, 1986, Agarwal, 1992 and 1997) as well as with specific relation to women's participation in community forest management in India (Nayak and Berkes, 2008) however the use of GIS to explore socio-ecological systems at this disaggregated level has so far also been under utilised.

2.5 Concepts in GIS based spatial analysis

The potential of GIS is starting to be realised (Rocheleau et al, 1994) however a number of barriers are evident. This includes knowledge of GIS tools, time and resources but also includes the use of technical cartographic language. This includes;

- **Scale**, which is the miniaturization of the world to a size which is small enough to fit onto a viewing platform. This influences spatial accuracy relating to generalization,

abstraction, displacement and simplification (Steinberg and Steinberg, 2006). The higher the scale a more accurate analysis is possible.

- **Projection** is the process by which the relative spherical earth is flattened into a two dimensional platform. Many projections exist and conversion between them is possible if the information is available on the original system used. Poor transformation and integration will cause features on the map to not align properly (Steinberg and Steinberg, 2006). Frequently UTM (Universal Time Meridian) is used but problems with unknown projections may occur with historic maps. This has been identified as a particular issue with spatial data in India (Ghosh and Dubey, 2009 and Agrawal, 2005).

- **Coordinates** are the system used to locate data geographically. These are used to geo reference images in GIS and convert into spatial data for analysis (Steinberg and Steinberg, 2006).

- **Datum** refers to the control points used by surveyors to locate features to the particulars of the Earth's surface (Steinberg and Steinberg, 2006). Commonly World Geodatic System 1984 (WGS 1984) is used which is globally consistent and used by GPS (Global Positioning Systems). Inconsistent spatial data can be transformed from one system to another with GIS tools provided that original datum is known. Without consistency in geographic references data inaccuracies in spatial analysis will increase (Foody, 2001).

2.6 Research questions

This research will respond to the following questions.

1. What is the spatial nature and distributions of different forest ecosystem services that forests provide to local 'communities', specifically in Orissa, India relating to cultural and provisioning services?
2. What does the disaggregated use of forest ecosystem services tell us?
3. What is an effective tool to examine the flows of ecosystem goods and services – does PGIS suit?

Chapter 3: Conceptual framework

The universal design principles developed in collective action theories involve seven main elements for efficient common property regimes (Ostrom,1990 and Agrawal, 2002). The first principle is ‘clearly defined boundaries’, which Ostrom (1990, p90) describes as ‘Individuals or households who have rights to withdraw resource units from the common pool resource must be clearly defined, as must the boundaries of the common pool resources itself‘. Ostrom (1990) stipulates that this is the first step in organizing collective action, with uncertainty in boundaries resulting in poor management and at worse destruction of the resource. This is remarkable similar to the uni dimensional approach of Hardin (1968) and is based on a stocks and flows model. This is stocks and flows approach is also used in the ecosystem services framework however ecosystem framework provides a more useful disaggregation of the resource into categories of ecosystem services which contribute to human wellbeing (MA, 2005). Critics of the design principles for common property regimes have argued that this model over simplifies the myriad of relations on which these socio-ecological systems are based (Johnson, 2004 and Cleaver, 2002) which often include overlapping and interlinked elements that defy simple modelling (Goldman, 1997). This criticism has also included the lack of attention to social process, which shape the flow and distribution of ecosystem services and are in fact an integral but fluid mediator within these systems (Cleaver, 2002, Bodin and Crona, 2009). Likewise a more people centred approach and attention to links to the wider social, cultural, political and economic and local context in collective action theories. These socio-ecological systems are non linear (Hamilton at el, 2007) and adaptive management scholars have emphasised the need to recognise the role of feedbacks across spatial and temporal scale (Folke, 2007). Feedbacks result from consequences of decisions and actions regarding resource use by individuals, households and differentiated social groups (Johnson, 2004 and Cleaver, 2002). Feedbacks involve adapting the elements of the system and components within it in a continuous learning (Gual and Norgaard, 2010) and, over longer timeframes, coevolution of the social and ecological components (Folke, 2007). Consequences which provide triggers for feedbacks include disputes that may escalate into conflict. These are dynamic and fluid over spatial and temporal scales. If these social processes remain unexamined or are poorly integrated within socio-ecological systems important factors for particular social groups may be hidden, with unintended consequences (Hamilton et al, 2007). With a wide range of actors and interests, forest common pool ecosystems involve a wide range of different components at multiple

scales (Peirce Colfer, 2005). Scale and feedbacks are essential factors in understanding these complex socio-ecological systems and their interrelated components.

In order to analyse the spatial boundaries of ecosystem services within a common pool forest resource a conceptual framework has been developed which places social groups, this case caste/ ethnicity/ gender groupings, at the centre as the primary unit of analysis. The flow of ecosystem services to these groups is mediated not only by institutions for forest management but also by social and resource boundaries locally and moulded through the links with the wider context in which this system is nested. The conceptual framework is therefore an attempt at a more integrated analysis of these systems, taking elements from the collective action approach as well as building on strengths from the entitlements approach.

A broad spatial analysis of provisioning ecosystem service has been selected as it involves direct use from ecosystems which is of vital importance to rural forest based livelihoods in Orissa and across India. Site based cultural services have also been include as these sites provide a valued space where socio-ecological norms and behaviours are created and reinforced through social processes (Raymond et al, 2009) and represent symbolic as well as material interests (Mosse, 1997).

This integration of approaches is raised by Johnson (2004), who highlights the need to align these two approaches, but who also emphasizes the challenges which this entails due to the different ideological backgrounds from which they have emerged. This adapted conceptual framework (Diagram 3.1 below) importantly provides a multi-dimensional perspective to spatially analyse how social and physical boundaries of cultural and provisioning ecosystem services regarding socially differentiated groups interact across the forest landscape.

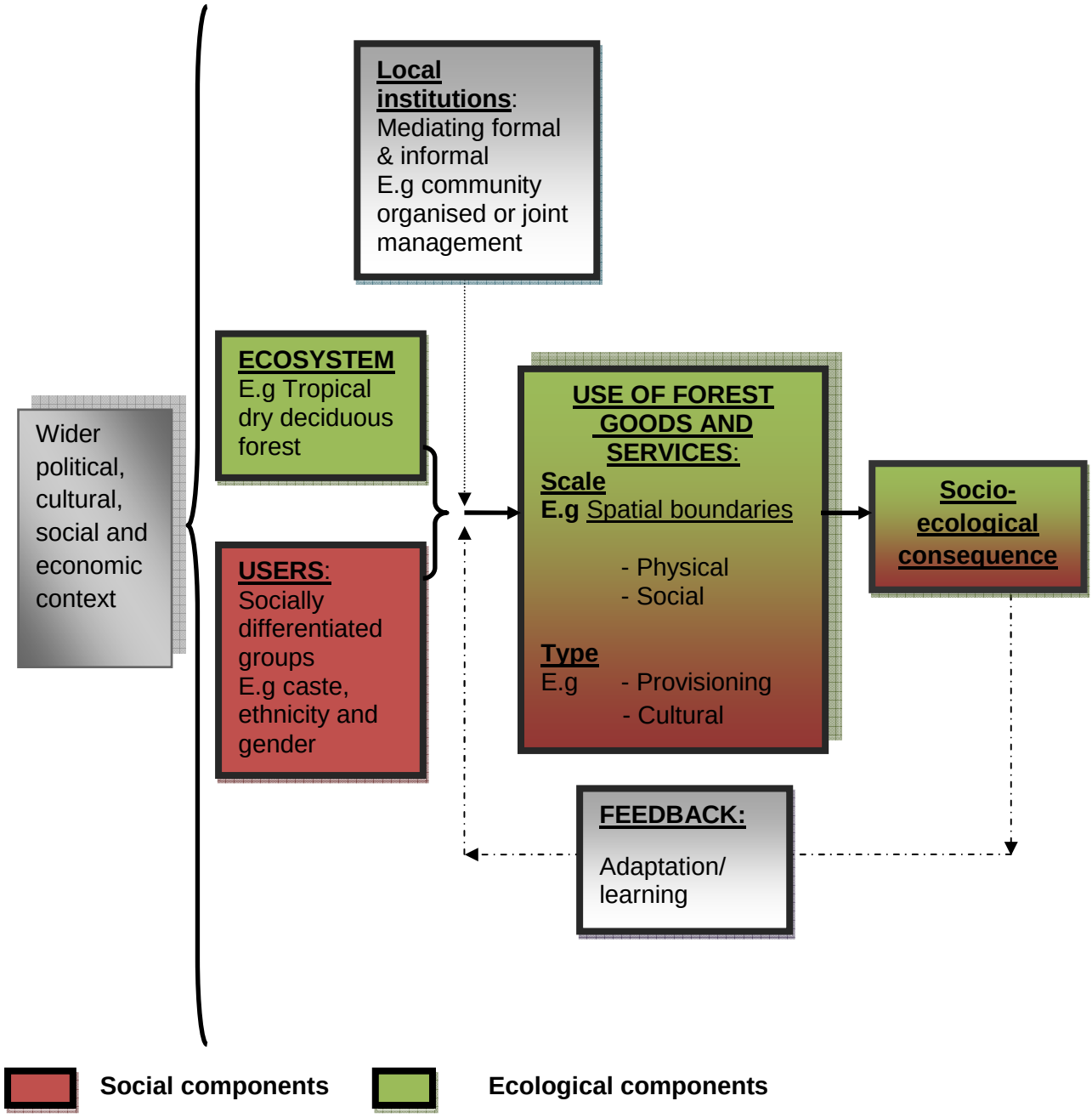


Diagram 3.1: Adapted conceptual framework for socio-ecological analysis of forest common pool resource

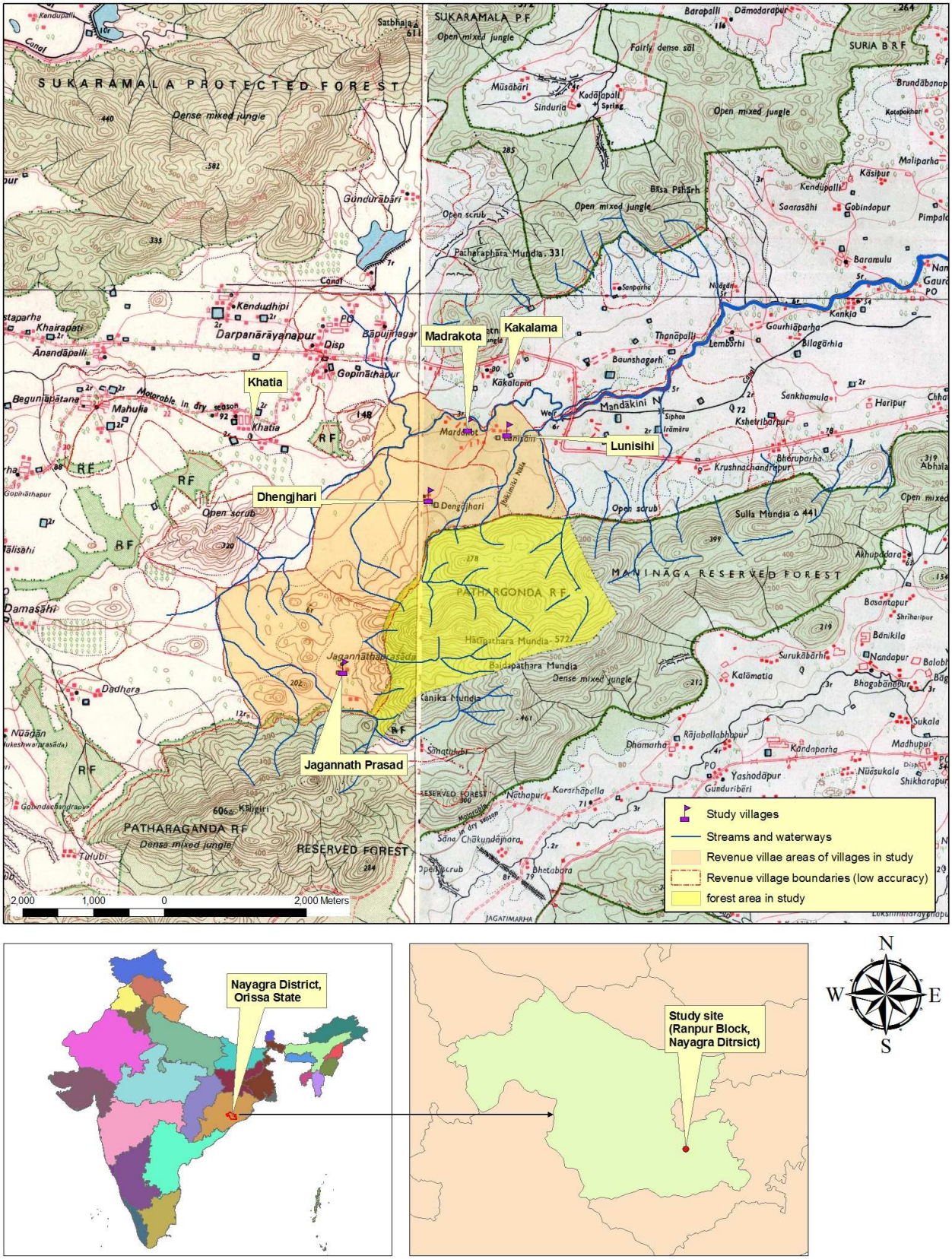
Chapter 4: Methodology

4.1 Approach

A Mixed methods approach developed using qualitative and quantitative strategies for data collection was applied in this research, the advantages of which include the ability to verify data and capture a wider range of views and interests. This is particularly useful in a heterogeneous and hierarchical context (Brewer and Hunter, 2006) such as the one in the study area. The qualitative methods were applied to identify forest goods are collected, by whom and where. These methods also provided an insight into the institutional, historic and links with the wider political, social, cultural and economic context within which the system is nested. Special emphasis was placed on social groups defined by gender and caste and ethnicity. The quantitative methods were used to corroborate and clarify the qualitative data and improve the spatial accuracy of landscape features and associated ecosystem domains of the social groupings. Largely primary data was collected using these methods however, some secondary data was used to provide a base for a richer spatial dimension to support the data collection and analysis process.

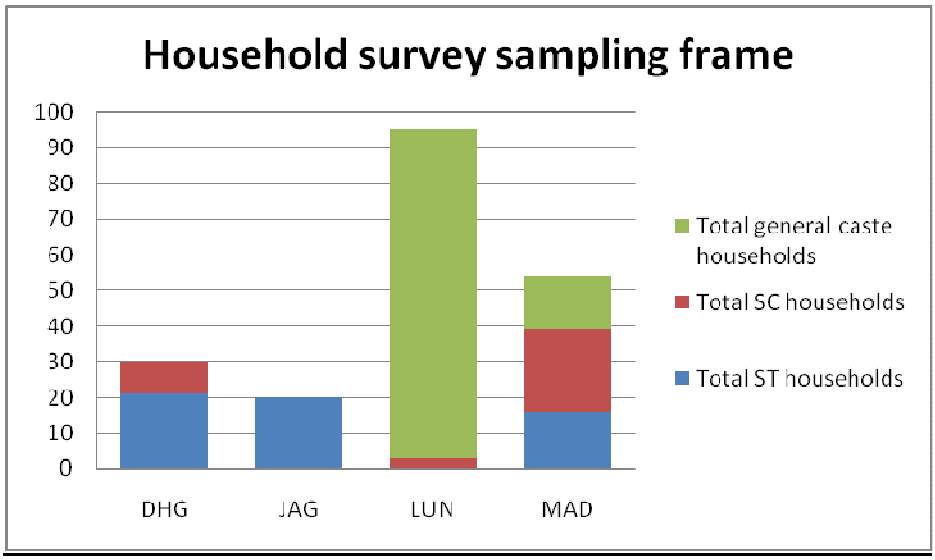
4.2 Sample Selection

Field work was conducted with four villages in relation to a nearby tropical dry deciduous forest area, as shown in Map 4.1. This forest extends long a ridge, producing a topographically diverse landscape with associated hill tops, valleys and rivers. These landscape features provided natural boundaries for historically for local people and for this study. However, clear landscape features were lacking to the south and east, where administrative boundaries were used to guide the area of study. This included the Reserve Forest boundary, clearly visible on Map 4.1, however additional forest areas below this line exist within the Revenue land below this, and if identified specifically by communities as important domains, these were also included. The Revenue boundaries are used as an approximation of the boundary between community forest areas, and this was used in the east of the study area also.



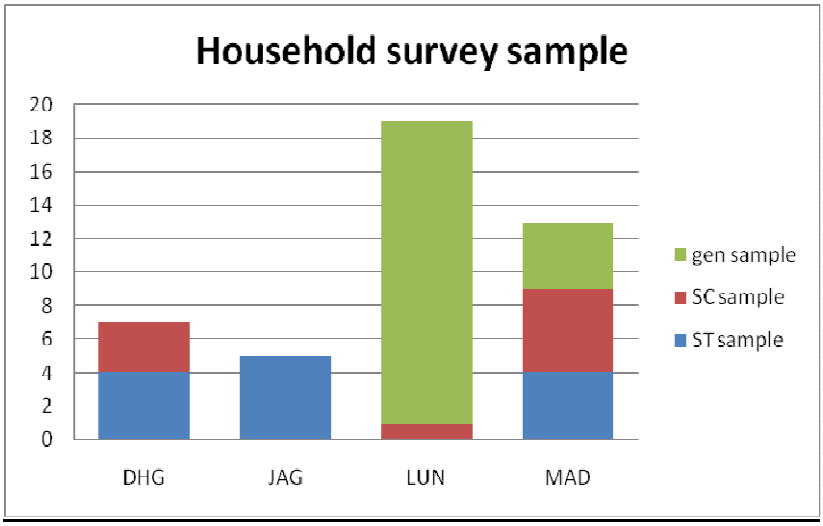
Map 4.1: The study site situated in Ranpur Block, Nayagra District, Orissa State, India

These villages were selected based on two main criteria. Firstly, caste and ethnic composition and secondly, use of the same forest common pool resource. A sampling frame (shown in Graph 4.1) was gathered from the 2001 Indian census and verified with villagers. Despite a number of other communities in the surrounding area using this forest area only four communities were included in this study due to time constraints.



Graph 4.1: Graph depicting the caste and ethnicity composition of each of the sample communities in the study.

Language and the need to sample across both gender and caste categories was facilitated by a two local research assistants, one male and one female. Due to time constraints data collection was undertaken throughout July 2011, although not ideal as this is the agricultural sowing season during which time participation in data collection activities was expected to be reduced. A stratified sub sample of 20% from each community (44 households in total) were randomly selected based on caste and ethnicity of households using the sample frame with community wealth rankings of households supporting this to ensure a representative sample which included any economic variation within each village. This sample composition is shown in Graph 4.2, which, when compared to Graph 4.1 indicates a representative sample was selected.



Graph 4.2 : Graph depicting the sub sample from each community based on ethnicity and caste in each of the communities in the study.

Specific ecosystem services were selected for spatial analysis by applying a bottom up, flexible approach which allowed participants to highlight the most significant services. Open questions were used and pre prepared lists avoided to allow the integration of local knowledge and use of toponomy to define spatial domains in the landscape. To facilitate the involvement of gender and caste based social groups, a flexible approach was used to respond sensitively to social barriers which constrained data collection (Cornwall, 2003).

4. 3 Data Collection Tools

Following group discussions regarding demographics and management of the forest, participatory mapping was undertaken with the aid of large Google Earth images of the surrounding landscape. Google Earth allows the display of varying landscape aspects (Goodchild, 2008), which was useful to provide a locally recognisable aspect consistent with the level of the eye as opposed to aerial views (Gooodchild, 2008) (see appendix 7.1). This also provided a relatively standard base from which to construct maps and identify community landmarks and ecosystem service domains relating to the realities of the geographic area. Prior to mapping watercourses, village locations and official administrative boundaries were highlighted on the images. The geographic accuracy of this data was unknown as it was digitised from historic topographic maps created in 1975, which were lacking in datum and projection representation, which is a particular issue relating to historic maps in India (Agrawal, 2005). In addition, the study site straddled two topographic map sheets, which were aligned and georeferenced using GIS. However, these boundary areas between map sheets are a known area of concentrated error during the digitising process

(Foody, 2001). The datum and projection 'India Nepal Everest 1956' was applied and transformed with GIS tools into the standard UTM WGS 1984 geographic projection but on testing this data, with identifiable locations on Google Earth, an approximate error of 30m was detectable in some localities. In addition watercourses naturally change path and are altered by human action and secondary digitised data such as the revenue village boundary layer may have been digitised at a low scale, thus creating inaccuracies when mapping at a higher scale. These accuracy issues were clearly communicated in community mapping activities with emphasis that this data only represented a rough guide to locations of these features. Where possible GPS was used to verify this data but spatial adjustment of GIS spatial data manually requires an equal spread of known geographically references features in the landscape and this was not always possible. Attempts to collect geographic locations of revenue village boundary stones was undertaken but often local knowledge was lacking to locate these features accurately in the landscape.

The of ecosystem domains were identified in the community mapping process by reference to landscape features and cultural sites which are key navigation cues for local people. These sketch maps were then used to plan transect walks in the forest with local guides to collect accurate GPS data for these landmarks and features, where possible, thus enabling the participatory element of data collection to be combined with GIS to enhance spatial analysis. Group discussions were also undertaken to provide historical, social and ecological and institutional context which influence the management and interaction of social groups within the landscape. Informal discussions were also conducted with the local Forest Federation organisation and local NGO to provide additional information relating to these factors. Lastly household surveys were undertaken with a sub sample in each community to assess any differentiation in the distribution of ecosystem services between gender and caste based groups (see appendix 7.2).

4.4 Data Analysis

ArcMap 9.3 provided the platform for the spatial analysis of data. Spatial analysis is an analytical process in which the position of the data geographically is an essential component of the analysis (Steinberg and Steinberg, 2006). ArcMap 9.3 provides a range of data integration and spatial analysis tools however, only basic tool were used in this process to transform and integrate secondary data on landscape features with a much greater emphasis in the study on the primary data collected with GPS. This GPS data was linked to data collected from the community maps, household surveys and group discussions about

ecosystem services to prepare the data for the visualisation process. Visualisation 'exploits the minds ability to readily see complex relationships in images, thus providing a clear understanding of phenomenon, reducing search time and revealing relationships that may otherwise not have been noticed' (Dodge et al, 2008). It helps reveal patterns which may be more evident than when using textual or numerical descriptions, although the additional use of these techniques was also applied in the overall analysis. Spatial analysis of ecosystem services was undertaken at a landscape level with spatial domains of ecosystem services for all four revenue villages. Secondly, this data was disaggregated to enable spatial analysis of ecosystem services relating to socially differentiated groups based on caste or ethnicity and gender. Thus, the spatial analysis was undertaken across two social scales at the landscape level for the provisioning and cultural forest ecosystem service categories.

4.5 Ethics

Ethical considerations, which concerns the moral behaviour of the research team (Gomm, 2009), were considered throughout the research process to avoid harm to participants (Gray, 2009). The conceptual framework, research questions and methods employed for data collection were all examined from an ethical perspective to ensure these principles were adhered to and procedures adopted to ensure standards were maintained. This included pre and post activity discussions with the local research assistants and obtaining written consent from participants (see appendix 7.3). Every effort was made to clearly communicate the objectives of the research (Rambaldi et al, 2006) and villagers were not coerced to participate in the study. Activities, where possible, were held at locations and times which would encourage the widest participation and representation of different social groups in each village. This was particularly, but not exclusively, important to gather data from general caste women who are more removed from public spaces and segregated in society. In interviews with scheduled caste and, to some extent scheduled tribe women were often conducted whilst fulfilling their household and community responsibilities. Confidentially was emphasized and maintained in relation to data collected in the household surveys with coding used to distinguish households. As is often the case with research related to social factors there was on occasion a difference between the ideal and the reality (Brewer and Hunter, 2006) and this was particularly evident in the community mapping process. The ideal situation was equal participation from all sub groups within each community to equally represent the spatial domains of ecosystem services in the forest, which frequently varies with gender and socio-economic status (Rocheleau and Edmunds, 1997). However, although inclusiveness was emphasized participation did vary, which was not ideal, however

power dynamics between socially differentiated groups were not openly challenged. There are tensions between some of the communities in the study due to different forest related values and interests, the allocation of rights, and historical events. When discussing emotive topics neutrality was therefore a key consideration.

Ethical considerations are also important in the data analysis and presentation phases of research, particularly with geographically visual techniques (Steinberg and Steinberg, 2006). However, this study did not include any household specific spatial domains, but linked household data to wider domains of social groups for specific ecosystem services. Where divergent views were collected from between and within the communities both of these views have been included in the analysis. Although it can not be claimed that this research will result in any resolution of these tensions, even with the mediation of local organisations, by maintaining neutrality the likelihood of inflaming tensions further was reduced.

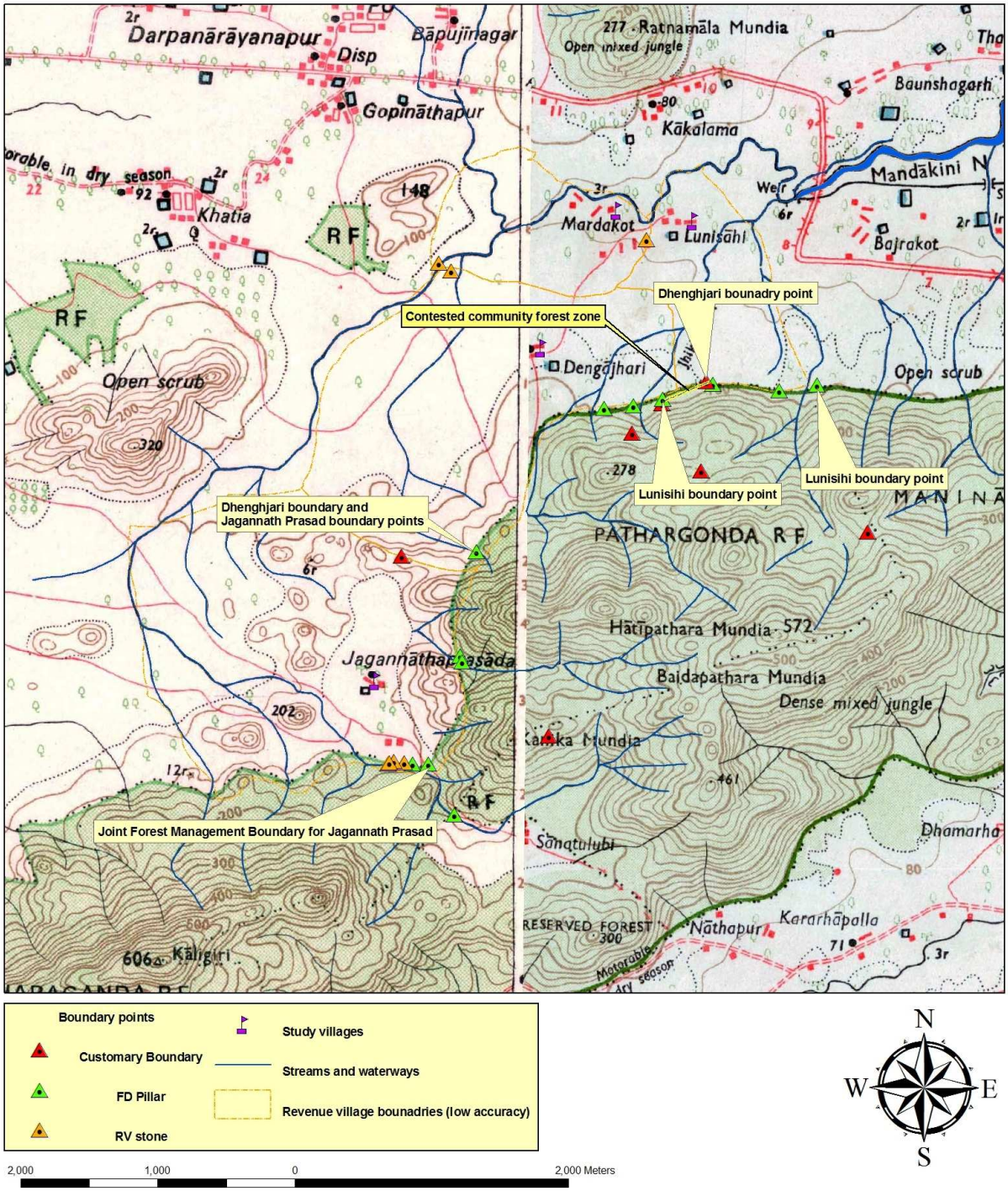
Ethical consideration also extended to the research team. Risk assessments and clear communication was emphasized throughout the data collection process, particularly relating to transect walks through the forest. These transects were planned based on the community maps and agreed with local guides prior to departure and any sites local guides were unhappy to visit were not included.

Chapter 5: Primary Data Analysis

5.1 Local context

Self initiated forest protection commenced in all four communities in the 1970's following a scarcity of forest goods. This raised awareness about the need for community protection to maintain livelihoods. Initially, combined forest protection was undertaken between Dhengjhari, Madrakota and Lunisihi communities. Jagannath Prasad observed the success of these initiatives, which triggered them also to begin protection. In the 1980's disputes erupted regarding the cutting of trees by Madrakota members. In the 1990's dispute turned to conflict with some violence against Madrakota members, which resulted in official complaints and continued for 12 years. As a direct result, livelihoods in both Lunisihi and Madrakota villages suffered. Dhenghjari remained neutral in this dispute partly due to close ties between the social groups in both communities. Unrelated to this, Lunisihi also experienced political divisions internally which resulted in a further dispute. As a result protection of the forest suffered and people from outside cut many trees in the Lunisihi forest area. This also occurred in neighbouring Bajrakote community during internal conflict. The Forest Federation (Maa Maninaag Jungle Suraksha Parishad) played a key mediating role in reducing and resolving some of these disputes and raised awareness about the need to protect the forest landscape as whole. Aside from this small SC hamlet were excluded from using the forest which is essential for their livelihoods. Following mediation from the Forest Federation Dhengjhari community agreed to allow this group to use a small section of their forest in the boundary area with Lunisihi. However, these households were unable to effectively protect this forest area and external parties once again took advantage to extract high value timber and degrade the forest. With high value timber being threatened in this area Lunisihi began protecting and as a result both Dhengjhari and Lunisihi now claim traditional rights over this section of forest and a boundary dispute is now apparent (as shown in Map 5.1) The Forest department during this time introduced JFM which Dhengjhari and Lunisihi benefited by securing formal rights to use the forest. However, Madrakota was excluded from this, due to the various local disputes and conflict. As a result, Madrakota do not have formal rights despite their traditional use of the forest and only use the forest to collect essential forest goods. There is a greater reliance now on the Revenue forested land for collection now, in addition to visiting other forests outside the study area. Revenue village forest however, is situated in an 'administrative black hole', with responsibilities shared between the Forest Department and the Revenue Department which often results in this

important resource for local people, particularly poor households and women, not being supported (Chatterji, 2001).



Map 5.1: GIS generated map showing customary boundary points, Forest Department (FD) boundary pillars for Reserve Forest Area and Revenue Department stones for Revenue Village boundaries.

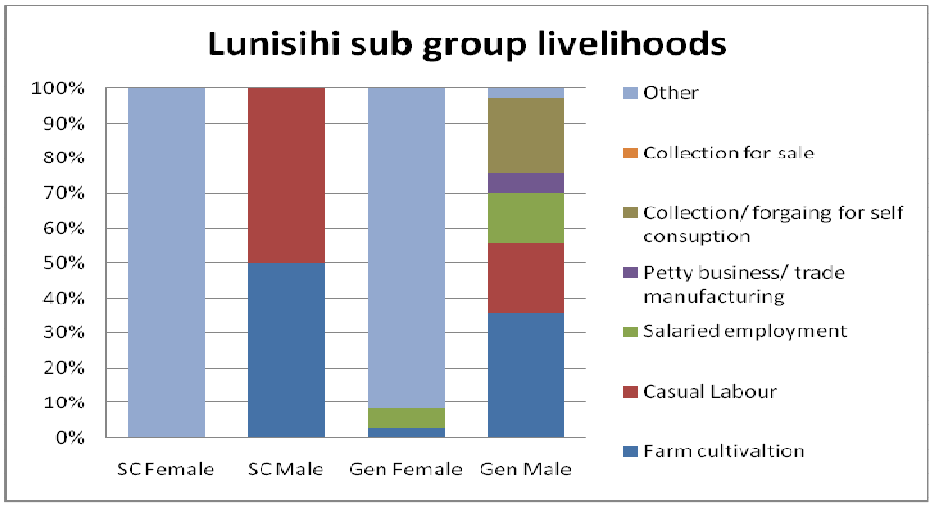
Jagannath Prasad on the other hand shared the eastern edge of the forest ridge and other Reserve forest outside the study area with neighbouring communities not included in this research. However, the Forest Department also introduced Joint Forest Management in this community, replacing the existing arrangements and reducing the area of forest available to Jagannath Prasad. This included a loss of access to an essential area for their livelihoods and caused disputes with the Forest Department and neighbouring communities. The social processes dynamics and links with wider political events are therefore have therefore shaped the current formal institutions which currently mediate the flow and distribution of forest ecosystem services from this forest.

Despite the gender stratification across most of Indian society, women in all four communities have played a central role in forest protection and conflict management. In the predominately tribal communities of Jagannath Prasad and Dhengjhari women undertake daily patrolling responsibilities with occasional support from the male members. In Lunisihi, which is 98% general caste households, women played a key role in harmonising the community during times of internal conflict, took up forest protection activities when the men of the village were distracted and organised communal development activities. Currently, women in Lunisihi monitor forest protection with forest patrolling activities, once again being the responsibility of male members of the households. Both male and female respondents from all villages in the study highlighted the problem of some male members fighting and arguing with people who broke the forest management rules as a major reason for women to take a more proactive role in forest patrolling.

5.2 Dependence on Forest Goods for Livelihoods

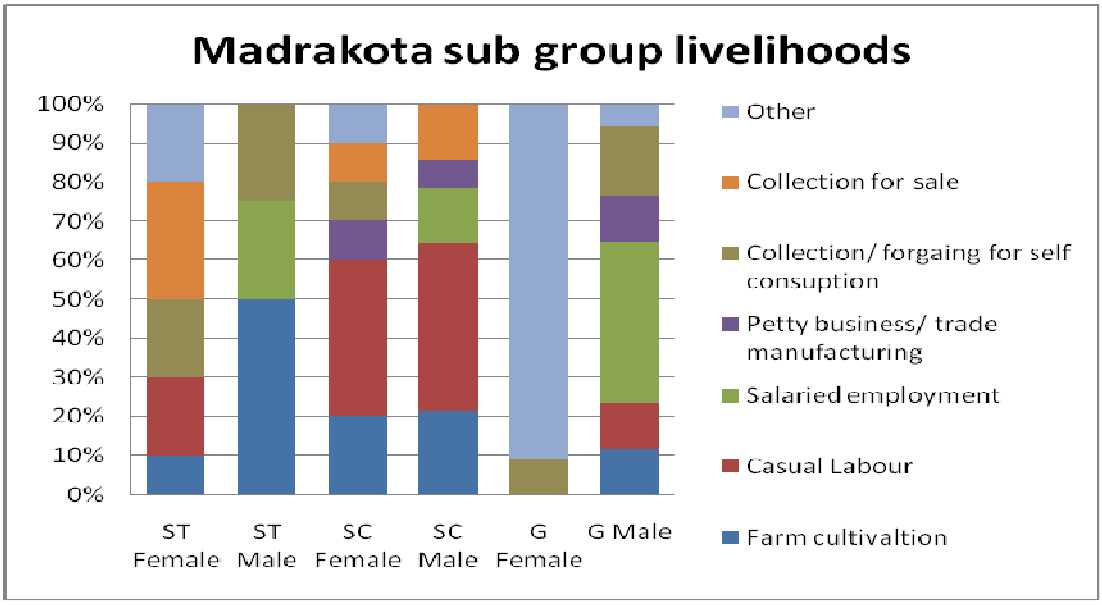
Lunisihi is a relatively homogeneous community containing 98% general caste households. Amongst this caste group women are segregated and their interactions in public spaces more controlled (Liddle and Joshi, 1986). This group is also characterised generally by having access to much wider social and economic opportunities (Cohn, 1971). However, scheduled castes, who constitute a very small number of households in Lunisihi, although much more marginalised and more prone to poverty across wider society (Gang et al, 2008), have been shown to emulate practices of the higher caste, which improves individual and household standing and wider acceptance within the local community (Dreze and Sen, 2004). These wider social processes are evident within the livelihood profiles of the socially differentiated groups within Lunisihi, with both general and scheduled caste women predominantly involved in work in the house (see Graph 5.1 below). The general caste male

household members have a diverse livelihood profile including salaried employment, business and agricultural cultivation. The less wealthy respondents (as identified by community wellbeing ranking) are engaged with agriculture on their own land and on other peoples land, as well as collecting a small number of forest products for household use. The direct dependence on the forest for livelihoods within the social groups of in Lunisihi village is therefore quite low but also varies with wealth.



Graph 5.1: The livelihood profiles of social groups within Lunisihi Revenue village.

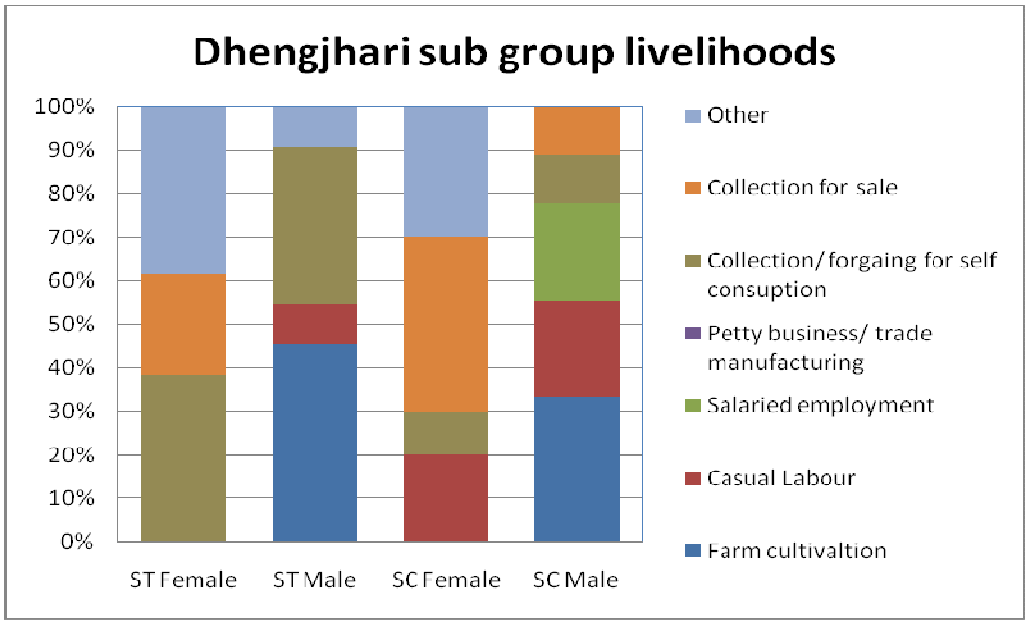
Similarly in Madrokota village general caste women also work predominantly in the house, with general caste men having a diverse livelihood profile although this is more dominated by salaried employment than agricultural activities. However, this similarity does not extend to the scheduled caste households, which are diveres but include a high proportion of casual labour as well as the sale of forest goods (see Graph 5.2). This indicates a higher reliance of this scheduled caste groups on forest goods. With the exception of salaried employment, which is just undertaken by the male members of this group, the livelihood profiles of the scheduled caste men and women in this village are broadly similar. This lack of gender differentiation within this group indicates that livelihoods needs are more of a priority for survival than social emulation of higher castes (Dreze and Sen, 2004).



Graph 5.2: The livelihood profiles of social groups within Madrakota revenue village.

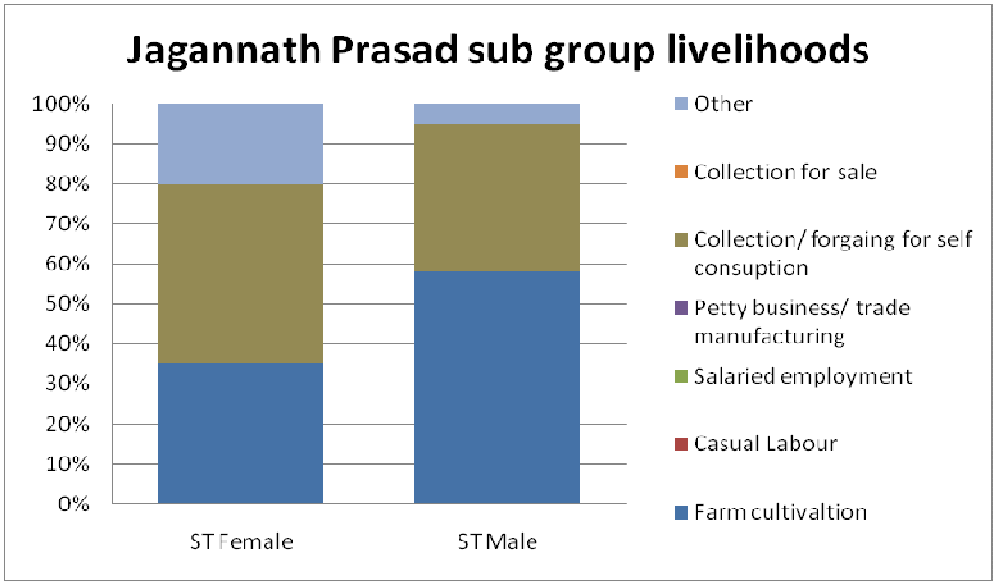
The scheduled tribe households however show a much higher reliance on forest goods for both male and female members. However, care must be taken in analysing this sample which involved a high proportion of female headed households. This may have skewed the results in showing a higher reliance of females on the sale of forest goods.

Dhengjhari contains 70% scheduled tribe households and 30% scheduled caste households. Both the scheduled caste and scheduled tribe households in this village for both men and women members have a high proportion of their livelihood directly from the collection of forest goods. This is slightly higher for the females in this group, although scheduled caste women having a higher reliance on forest goods for sale whereas scheduled tribe women predominantly collect for household use (see Graph 5.3 below). Male members of both these groups however, are also involved in casual labour.



Graph 5.3: The livelihood profiles of social groups within Dhengjhari revenue village.

Jagannath Prasad is also a relatively homogeneous village, containing only scheduled tribe households. The livelihoods profile of both men and women also reveal a high reliance on forest goods (see Graph 5.4 below). Again, this is more pronounced for the female members of households with both male and female groups collecting solely for household use. The lack of collection for sale may be influenced by the poor access to markets in this village.

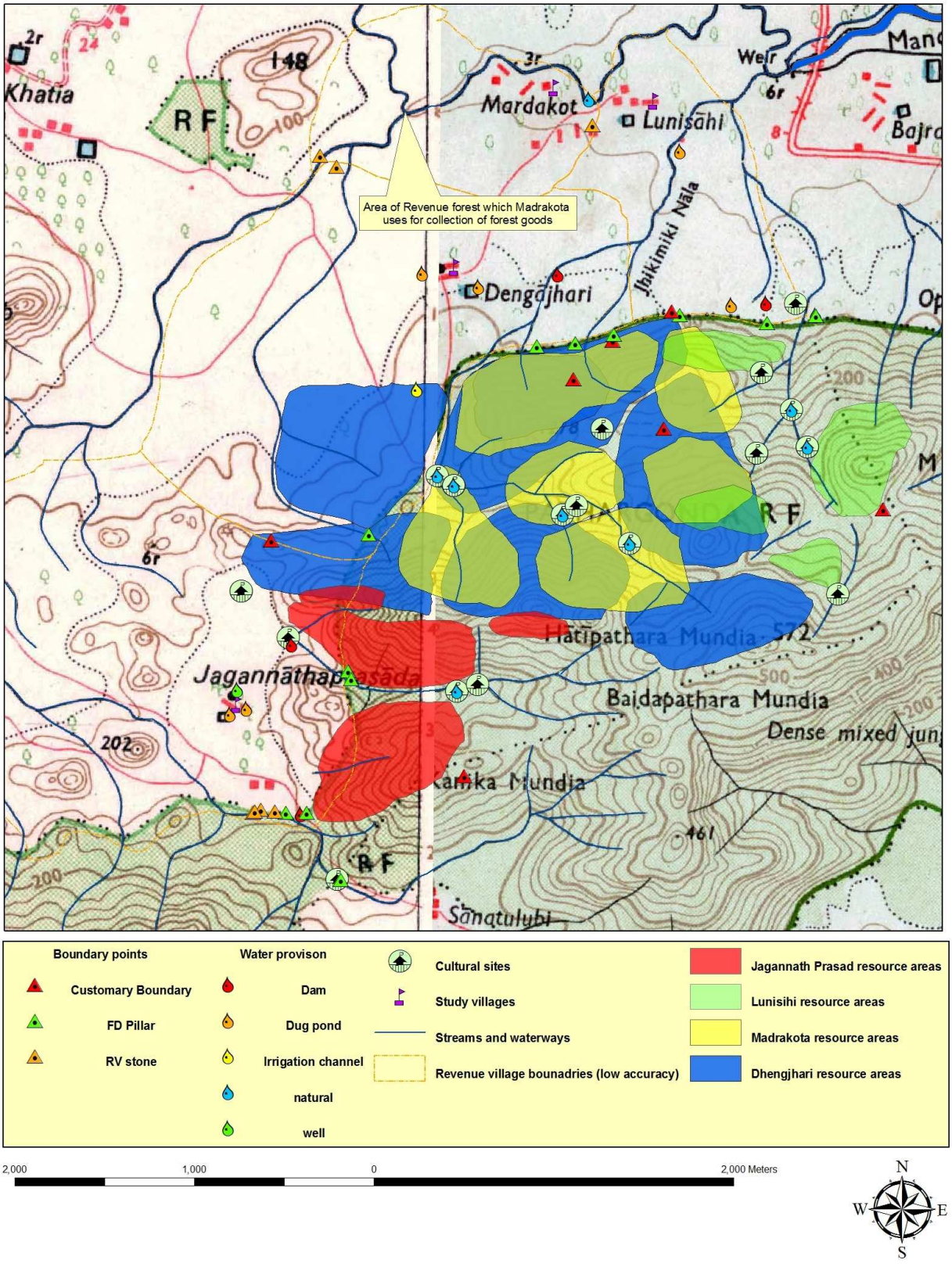


Graph 5.4: The livelihood profiles of social groups within Jagannath Prasad revenue village.

These livelihood profiles of the social groups within villages indicate a pattern relating to gender and caste/ ethnicity and forest dependency.

5.3 Community Spatial Domains of Forest Provisioning Ecosystem Services

As expected, even in a study of only four villages, there is considerable spatial overlap of ecosystem services between villages. This is particularly the case with regard to spatial domains of Madrakota village, which does not have formal rights under JFM to use the forest. There is also overlap in the boundaries between the village which have formal rights. This may reflect the mix of traditional and modern institutions (Rocheleau and Edmunds, 1997). Some customary boundary markers were recorded (as shown by the red triangles in Map 5.2) however, these do not sho an clear spatial pattern. The mapping of provisioning ecosystem service spatial domains revolved around important community landmarks which included rivers, hilltops and cultural sites in the forest. This may account for some of the gaps between domains evident particularly with regard to Dhengjhari. As expected ecosystem service flow did not always correspond to administrative boundaries from the Forest Department (FD) or Revenue Department (RV) despite the later being cited as the demarcation points between provisioning ecosystem service spatial domains. The concentration of multiple spatial domains with the vicinity of the Dhengjhari and Lunisihi forest boundary is a result of the differing perceptions about the boundary in the forest (as shown in Map 5.1) and the customary use patterns by Madrakota villagers.



Map 5.2: GIS map of the spatial forest ecosystem service (provisioning and cultural) flows to the communities in the study.

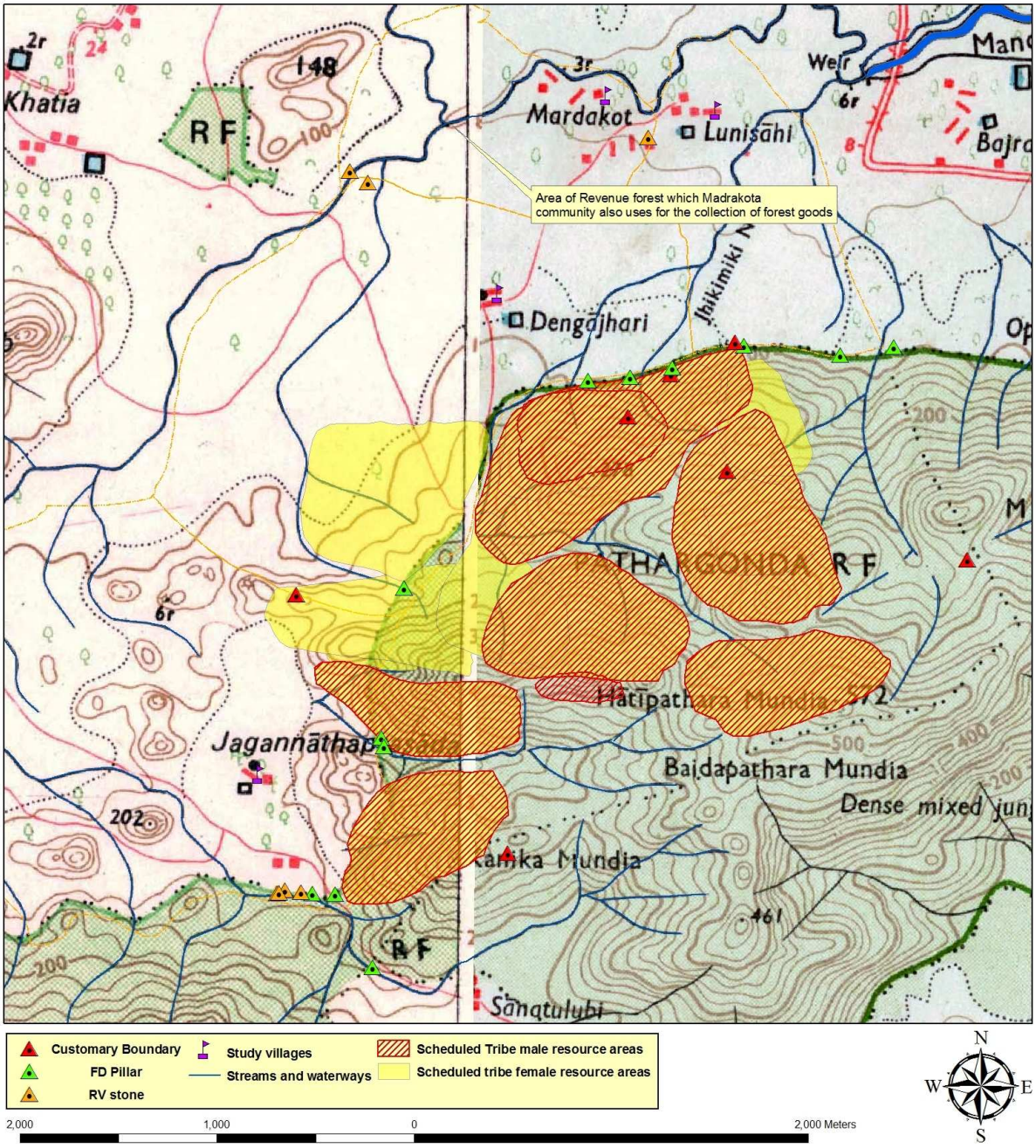
5. 4 Spatial Domains of Caste, Ethnicity and Gender based Socially Differentiated Groups of Forest Provisioning Ecosystem Services

There is significant overlap between the spatial domains of the social groups within the study based on caste and gender, which reflects the geographic dispersal of the social groups in the study. However, some additional patterns are also evident which can be attributed to links with the wider social and cultural context and local context in relation to disputes surrounding the use and protection of the forest. By incorporating further contextual information regarding the livelihood profiles and the number and type of forest goods, (identified in group discussions and household interviews) begins to reveal further patterns influenced by social factors.

5.4.1 Scheduled Tribe and Gender groupings

The spatial analysis for gender and scheduled tribe show that there is a large amount of overlap in the spaces used by these groups to collect forest goods (see Map 5.3). However, women in this group cover a wider and more diverse area of forest, which includes large areas in the lower part of the forest area which includes forest in the lower forest section in revenue land. Only women in this group collect in these areas, which includes sections in Jagannath Prasad formal use area. This is the result of customary use patterns and peaceful co-existence . There is however much more overlap of spatial domains in the Reserve forest area which includes areas in the disputed zone between Dhengjhari and Lunisihi forest. This again highlights the influence of customary use patterns. There are therefore, some identifiable gendered spatial domains for within this social group.

However, further analysis of the type of forest goods collected (as shown in Table 5.1 below) identified in household surveys, reveals that although in general there is more gender equality within scheduled tribe populations (Mitra, 2008), there is still a significant gender division in the collect of different forest goods. This is however, not clearly highlighted within the different livelihoods profiles or mapping. This highlights the value of additional multi dimensional investigations to also include the household scale. The gendered spatial domains of the use of natural resources was also shown by Rocheleau and Edmunds (1997) in a study in Africa which used participatory sketch maps to highlight the relationship between space, ecosystem services and gender at the household and resource scale scale.



Map 5.3: GIS generated map of the forest provisioning ecosystem service spatial domains of scheduled tribe populations disaggregated by gender.

	Dhengjhari (DHG)		Jagannath Prasad (JAG)		Madrakota (MAD)	
	ST Females	ST Males	ST females	ST males	ST females	ST Males
Firewood	✓	×	✓	✓	✓	×
Bamboo	×	✓	×	✓	×	✓
Timber	×	✓	×	✓	×	✓*
Tubers	✓	×	✓	×	✓	×
Medicinal Plants	✓	✓	✓	✓	✓	×
Siali Leaves	✓	×	✓	×	✓	×
Sal Leaves	✓	×	✓	×	✓	×
Kendu Leaves	✓	×	✓	×	✓	×
Teak Seeds	×	✓	✓	×	✓	×
Karianja seeds	×	×	✓	×		×
Mahua flowers	✓	×	✓	×	✓	×
Mahua Seeds	✓	×	✓	×	✓	×
Mushrooms	✓	×	✓	✓	✓	×
Hill broom	×	×	✓	×	×	×
Kendu fruit	×	×	×	×	×	×
Bela	✓	×	×	×	×	×
Small black fruit	✓*	×	×	×	×	×
Siali Bark	×	✓	×	×	×	×
Dat leaves	✓	×	×	×	×	×
Honey*	×	✓	×	✓	×	×
Green leaves	×	×	✓	×	×	×
Sal resin	×	×	✓	×	×	×
Bitter Gound	×	×	×	✓	×	×
Kankada	×	×	×	✓	×	×
Bamboo flowers	×	×	×	✓	×	×
Madhamalati flowers	✓	×	✓*	×	×	×
TOTAL	**13**	**6**	**15**	**9**	**10**	**2**

Forest service not identified as being collected community

Forest service identified as being collected by

*(source: household survey and community mapping) * not identified in household survey*

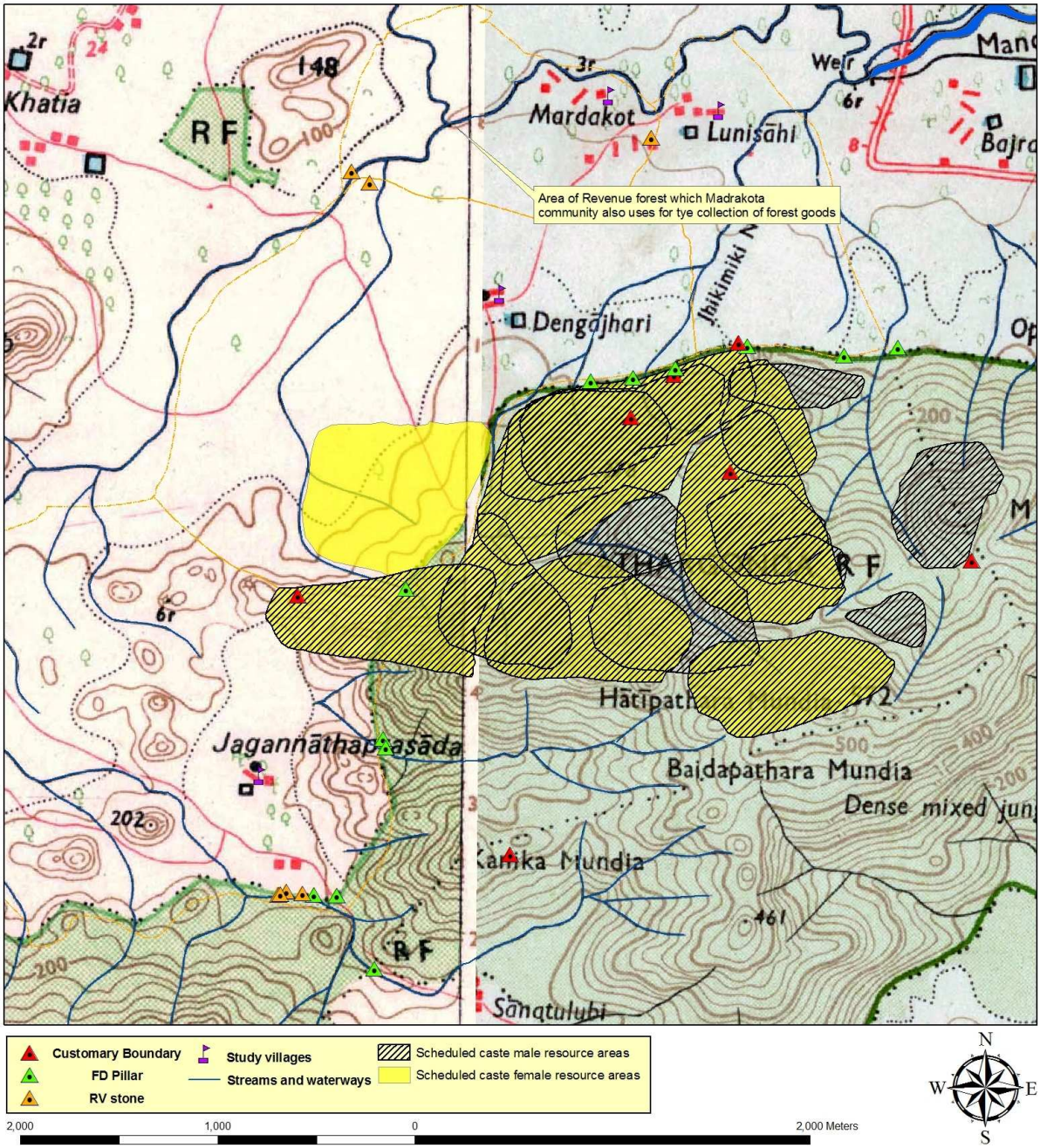
Table 5.1: Disaggregation of provisioning ecosystem services for scheduled tribe and gender groups

5.4.2 Scheduled Caste and Gender groupings

Spatial analysis of provisioning ecosystem services for scheduled caste and gender groups show a more pronounced gendered patterns. Similar to the scheduled tribe analysis only women collect forest goods in the lower forested area below the administrative Reserve forest boundary (RF in Map 5.4 below). There are more pronounced male domains for forest goods also identifiable in the upper and eastern areas of the study area. Scheduled caste populations are distributed within all villages except Jagannath Prasad, the influence of the geographic dispersal being clearly visible. However, there is not uniformity in the type or number of forest goods collected by each scheduled caste households from each of the villages and further disaggregation to include gender dimensions reveals greater variation (see Table 5.2 below).

This data, collected from household surveys and community mapping, shows that within Dhengjhari community the scheduled caste (SC) households collect a number of different forest goods however, this is predominantly undertaken by the female members of households. Madrakota SC women also are the predominate collectors of goods in the forest, although there are similarities in the types of products these geographic groups collect, Madrakota collect far fewer in number, 11 in total compared to 18 by Dhengjhari. This is a reflection of distance from the forest but also the lack of formal rights, which respondents from Madrakota said had resulted in only essential collection of forest goods due to occasional harassment from the other communities. As a result, they rely more heavily on the nearby revenue forested land (as highlighted in Map 5.4). Lunisihi village only has a very small number of SC households and a large number of general caste households. This may help explain the large gendered differentiation of forest goods and also the smaller number of goods collected reflecting an emulation of the higher caste social norms within this population and access to other livelihoods, including casual labour to serve the higher caste households. Also, these groups may have wider livelihood options through proximity to a large number of general caste households with the service of lower caste members to higher caste households being a key component of the caste system (Gang et al, 2008).

Although Madrakota also contains higher and lower caste categories this pattern is not as pronounced in this village, which is much poorer, as identified in community wealth ranking and therefore survival becomes higher priority (Dreze and Sen, 2004).



Map 5.4: GIS generated map of the forest provisioning ecosystem service spatial domains of scheduled caste populations disaggregated by gender.

	Dhengjhari (DHG)		Madrakota (MAD)		Lunisihi (LUN)	
	SC Female	SC Males	SC Female	SC Male	SC Female	SC Male
Firewood	✓	✓	✓	✓	×	✓
Bamboo	×	✓	×	✓	×	✓
Timber	×	✓	×	✓*	×	✓*
Tubers	✓	×	✓	✓	×	×
Medicinal Plants	✓	×	×	×	×	×
Siali Leaves	✓	×	✓	×	×	×
Sal Leaves	✓	×	✓	×	×	×
Kendu Leaves	✓	×	✓	×	×	×
Teak Seeds	✓	×	×	×	×	×
Karianja seeds	✓	×	×	×	×	×
Mahua flowers	✓	×	✓	×	×	×
Mahua Seeds	✓	×	✓	×	×	×
Mushrooms	✓	×	✓	✓	×	×
Hill broom	✓	×	×	×	×	×
Kendu fruit	✓	×	×	×	×	×
Bela	✓	×	×	×	×	×
Small black fruit	✓	×	×	×	×	×
Siali Bark	×	×	×	×	×	×
Dat leaves	×	×	×	×	×	×
Honey*	×	×	×	×	×	×
Green leaves	×	×	×	×	×	×
Sal resin	×	×	×	×	×	×
Bitter Gound	×	×	×	×	×	×
Kankada	×	×	×	×	×	×
Bamboo flowers	×	×	×	×	×	×
Madhamalati flowers	✓	×	×	×	×	×
Total	**16**	**3**	**8**	**5**	**0**	**3**

Forest service not identified as being collected

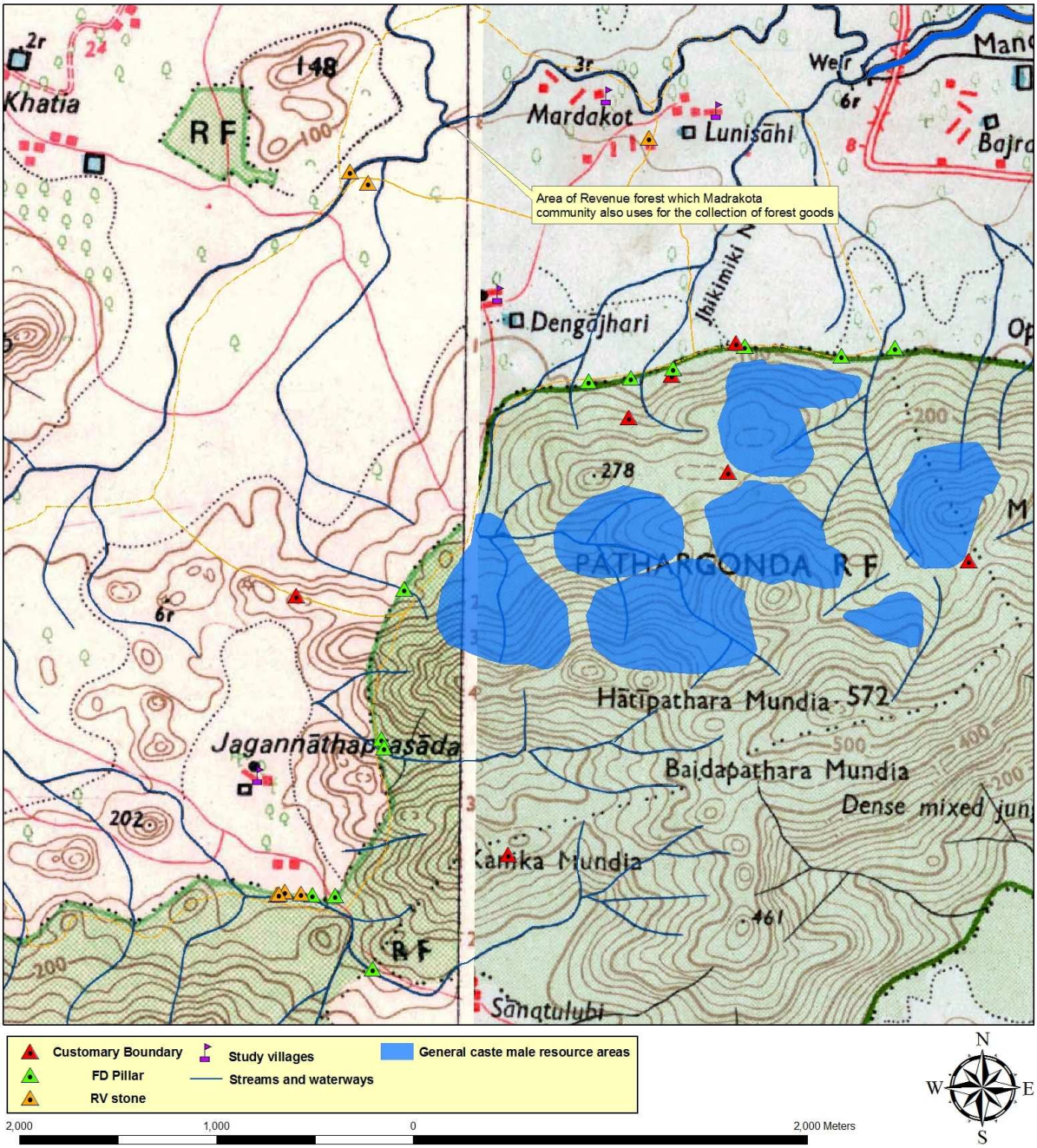
Forest service identified as being collected by community

*(source: household survey and community mapping) * not identified in household survey*

Table 5. 2: Disaggregation of provisioning ecosystem services for scheduled caste and gender groups

5.4.3 General Caste and Gender groupings

Rising through the caste system to analyse the general caste populations shows an even more pronounced pattern of gendered domains of provisioning forest ecosystem services. Within higher caste households women are segregated in many public spaces and more confined to work within the house (Liddle and Joshi, 1986 and Desai and Krishnaraj, 2004). As a result general caste women do not collect goods in the forest and the spatial domains are completely male dominated (see Map 5.5 below). These domains are somewhat dispersed across the landscape but mainly confined to the upper areas. This is partly due to geographic dispersal of general caste households within Madrakota and Lunisihi village areas but also reflects the type and number of goods collected (as shown in Table 5.3 below). General caste households mainly collect bamboo and, firewood with timber being harvested collectively on a 5year rotational basis from plantation areas on revenue land. A small number of smaller households also collect mushrooms and siali bark for binding timber in houses building. This is consistent with the livelihood profile of these groups which reflect much wider economic and social opportunities (Mitra, 2008) which mould different values and interests relating to the forest.



Map 5.5: GIS generated map of the forest provisioning ecosystem service spatial domains of general caste populations disaggregated by gender.

	Madrakota (MAD)		Lunisihi (LUN)	
	General caste Female	General caste Male	General caste Female	General caste Male
Firewood	×	✓	×	✓
Bamboo	×	✓	×	✓
Timber	×	✓*	×	✓*
Tubers	×	×	×	×
Medicinal Plants	×	×	×	×
Siali Leaves	×	×	×	×
Sal Leaves	×	×	×	×
Kendu Leaves	×	×	×	×
Teak Seeds	×	×	×	×
Karianja seeds	×	×	×	×
Mahua flowers	×	×	×	×
Mahua Seeds	×	×	×	×
Mushrooms	×	×	×	✓
Hill broom	×	×	×	×
Kendu fruit	×	×	×	×
Bela	×	×	×	×
Small black fruit	×	×	×	×
Siali Bark	×	×	×	✓
Dat leaves	×	×	×	×
Honey*	×	×	×	×
Green leaves	×	×	×	×
Sal resin	×	×	×	×
Bitter Gound	×	×	×	×
Kankada	×	×	×	×
Bamboo flowers	×	×	×	×
Madhamalati flowers	×	×	×	×
Total	**0**	**3**	**0**	**5**

Forest service not identified as being collected

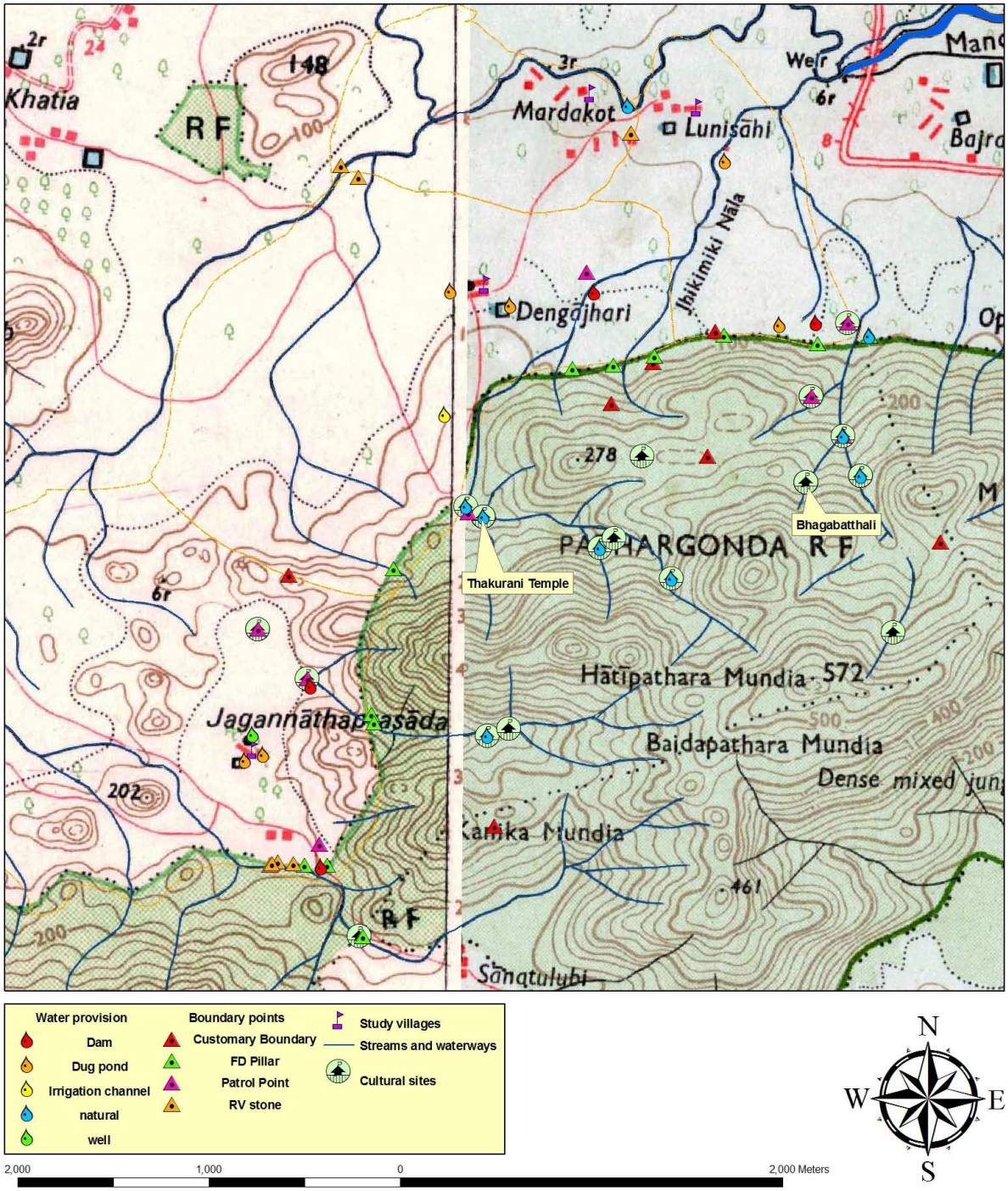
Forest service identified as being collected by community

*(source: household survey and community mapping) * not identified in household survey*

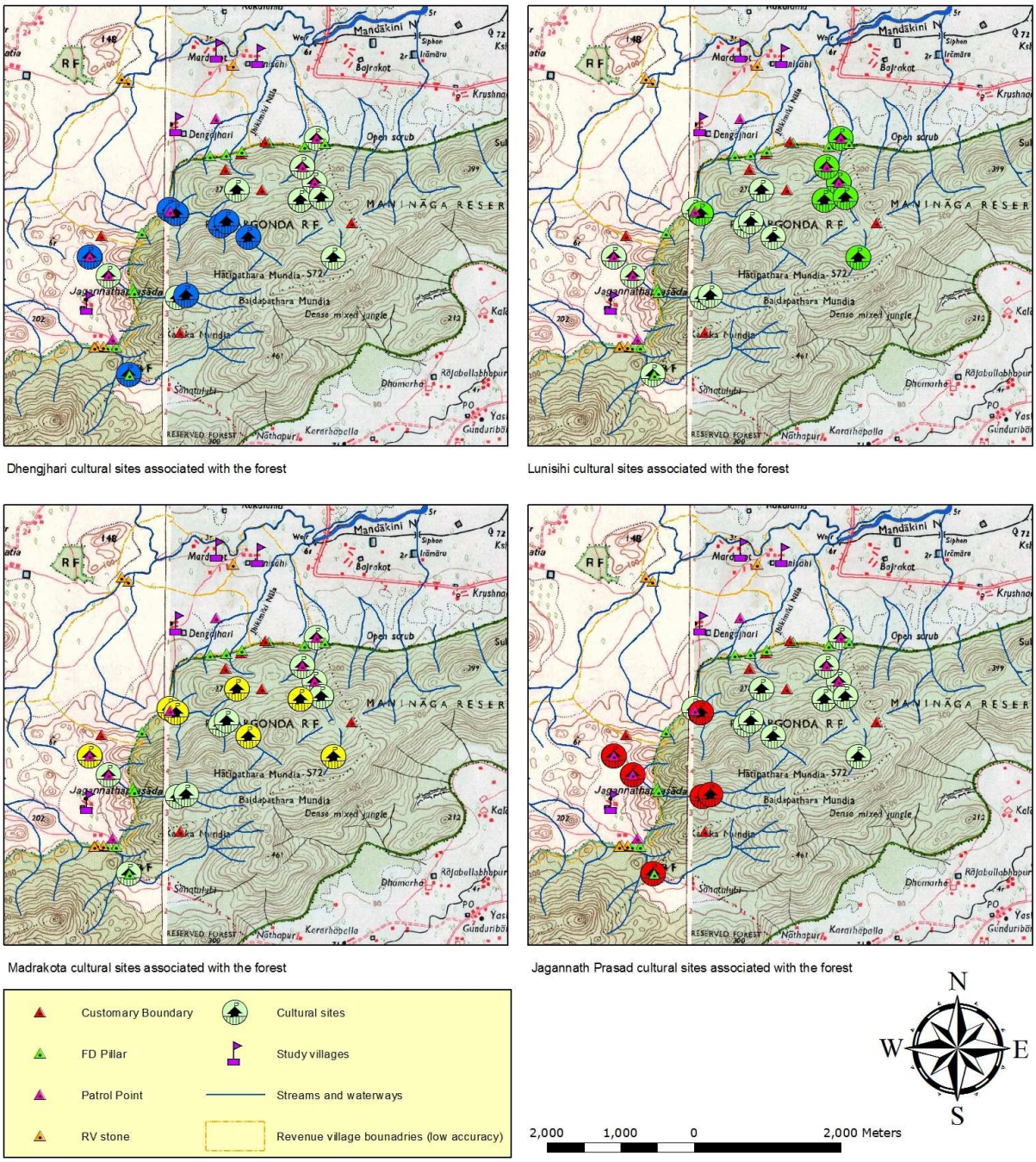
Table 5. 3: Disaggregation of provisioning ecosystem services for general caste and gender groups

5.5 Spatial Domains of Forest Cultural Ecosystem Services

The community mapping centred around identification of community landmarks which the community use as navigation points in the forest. These landmarks included natural features, such as hills, which were identified using Google Earth, streams and sites with local cultural significance. These locations included trees and stones, which were used as rest points in the forest and often patrolling locations. Also included were large clearings with vistas, waterfalls and clearings often associated with streams where people and cattle took rest and for refreshment (see Map 5.6 below). These sites are therefore closely associated with forest ecosystem provisioning service domains across the landscape by social groups using the forest, (as indicated by Map 5.7). In addition however to this practical use, respondents in the household survey identified sites by streams which are valued intrinsically, for example picnic sites for youths from Lunisihi. A number of religious and spiritual sites were identified in the study area however, not all could be accurately mapped (and therefore were not included in the spatial analysis). This included ‘The lonely place’ in Dhengjhari where local people go for spiritual reasons.



Map 5.6: GIS generated map of the forest site based cultural ecosystem service across the landscape.



Map 5.7: GIS generated map of the forest site based cultural ecosystem service across the landscape disaggregated to the village level.

Two cultural sites included in the study were identified through the household surveys and mapping as being particularly culturally significant which also had particular gender dimensions over and above those associated with direct collection of forest goods (shown in Map 5.6). The first is Bhagattahli in Lunisihi, which is an open grass covered space with views across the landscape. This is used for religious festivals by Lunisihi villagers, which involves a feast in aid of overall community wellbeing. As with much of the social life in this

village dominated by general caste households, only male members participate. Secondly, Thakurani Temple in Dhengjhari forest, identified across all villages in household surveys, is shrouded in local myth to emphasize the importance of trees. Three festivals are held here, also with clear gender dimensions. Two of these festivals are only attended by male members from surrounding villages and relate to good rainfall and safety in the forest. The third festival focuses on siali leaves, which are an important forest product which female members of scheduled caste and tribe households collect for household use and sale. Along with a feast, women from surrounding villages gather to plant siali seeds wrapped in animal dung to encourage tree growth. Although only women participate in these activities men also attend. These events signify important events in the social life locally. In discussions with Madrakota people it was highlighted that due to community tensions surrounding conflicts over tree cutting. Madrakota have for some years not participated in these festivals. However, recently relations have improved and last year they attended allowing a reinforcement of social networks across the similar social groups in these villages (Bodin and Crona, 2009). This shows the importance of social networks and participation in social events at these forest based cultural sites (Deb, 2009) and highlights the links between the flow of ecosystem services and social processes through feedbacks between components of these complex socio-ecological systems (Cleaver, 1997).

Chapter 6: Discussion

This analysis shows a complex, multilayered spatial pattern in the flow of ecosystem services to social groups across the landscape. However, this is not spatially distributed evenly reflecting ecological dimensions, differing interests and values and social norms. This complex network of ecosystem service distribution was also highlighted by Hamilton et al (2007) and demonstrates how social behaviour determines how space is used. Gendered caste/ ethnicity spatial domains are visible, as is the hierarchical and patriarchical nature of the caste system in the use of space. Further understanding and nuisances relating to these dimensions become available when integrating this spatial data with other qualitative and quantitative data on specific forest goods. This reveals that these social divisions stretch across scales to include trees. For example the siali leaves are collected by scheduled caste and tribal women, whereas the bark and timber is a collected by men. These micro scale gendered spatial domains of forest goods were also demonstrated by Rocheleau and Edmunds (1997) in a study in Africa.

The close association between cultural and provisioning ecosystem services is clearly visible in the spatial analysis and demonstrates the overlapping nature of ecosystem services across and landscape between and within social groups. This was also clearly shown by Peluso (1996) through the ethics of accessing trees in Indonesia with temporal and spatial divisions. This emphasizes that social and ecological boundaries are interconnected, and complex which the spatial analysis of both cultural and provisioning ecosystem services across gender and caste groups clearly highlights. The additional contextual detail accompanying this spatial analysis provides a deeper understanding of the dynamics of these relationships, which are in reality quite fluid, particularly relating to the temporal gender domains and cultural and social significance of the more valued cultural sites, specifically Thakurani temple. These sites provide space for social and cultural activities and reinforce behaviours and interests surrounding the collection of forest goods, a process which is evident across other sacred forest sites in India (Deb, 2009). The festivals held at these sites provide space for relationship building within and across social groups and encourage adaptation of these local social processes which can be drawn upon in times of conflict and change and establishment of coexistence and peace (Bodin and Crona, 2009). However, some wider social norms can be deeply embedded in conscious and unconscious decisions and actions which are reinforced at these sites, particularly gender and caste based norms (Rocheleau and Edmunds, 1997 and Mosse, 1997). These socio-ecological systems

therefore not only contain material goods, expressed frequently as assets in system based models such a collective action and ecosystem services frameworks, but also consist of social and symbolic processes. This important component is often overlooked in simplistic models however, the integration of political ecology approaches, such as those applied in the entitlements school, can enrich understanding of these complex systems.

The role of cultural codes for which these cultural sites provide a focus, are strongly linked to well being and a desire for peaceful co-existence (Cleaver, 2002). Poorer and marginalised social groups may have less time to invest in strengthening social bonds in daily life, making these sites and cultural festivals important social events. Conflict is part of life, although it can increase when new social and physical boundaries are imposed through new formal institutions such as JFM. These new institutional arrangements are often modelled on the mainstream common property regimes models and universal design principles developed through the collective action school. These can oversimplify, overlook customary use patterns and fix previously fuzzy boundaries and leave less room for important dynamic social processes. Indeed, Nayak and Fikret (2008) and Saito-Jensen and Jensen (2010) both showed that bundles of rights changed as JFM was established in India, with institutional structure resulting in a decline in these bundles. This is evident in the exclusion of Madrakota village and in Jagannath Prasad whose forest area with the introduction of new social and physical boundaries under new JFM arrangements. These new institutions can also reduced social links horizontally in favour of more vertical, less diverse social links with the Forest Department (Nayak and Fikret, 2008) hence reoding important social processes and weakening the institutions.

The link between informal institutions in shaping formal institutions and contributing to their success is underemphasized in the mainstream models and the concept of a universal blue print for common property regimes is an attempt to engineer institutions within a complex and dynamic space (Johnson, 2004). Indeed these models reiterate the principle of the selfish individual, which was a key component of Hardin's theory (1968) (Goldman, 1997).The lack of flexibility in this approach leaves less room for adaption and learning. Conflict is a good example of such a dynamic process, illustrated by the case of general caste women reacting to political divisions which resulted in a lack of forest protection. Despite the wider social norms surrounding the behaviour of this social group, women were able to push these social boundaries and began patrolling the forest, organise collective activities and encourage conflict resolution through an active women's group. This was only possible with the space provided locally by these social processes and networks. Policy which formalises social and physical boundary based the collective action model and

structured universal design principles risk over simplify these complex systems and not recognising the importance of dynamic social processes (Cleaver, 2002). As history and customary patterns are ignored and boundaries fixed there is less flexibility and space for adaptation, constraining the feedback process which shape the flow and distribution of ecosystem services across social groups. Fixing of social and physical boundaries in this way may benefit some by securing livelihoods, but can also result in a loss of livelihood security for other, more marginalised social groups.

Chapter 7: Conclusions

PGIS is a technique which provides a platform for increasing the interests and values of a more diverse range of social groups and ecosystem services represented through multilayered maps. It allows the integration of both qualitative and quantitative data from a wide range of sources and analysis across a wide range of scales (Elwood, 2010), which has so far been under utilised in spatial analysis of socially differentiated groups. It allows a more holistic enquiry of the landscape and the socio-ecological interactions which shape it over spatial and temporal scales. Mixing this with other tools allows the potential for a much deeper analysis and, although this study include only a broad analysis across various social groups and ecosystem services it demonstrates the potential for this tool to be utilised in more in depth studies of these complex, non linear systems. This is particularly important as more simplistic, stocks and flow models have a strong influence on interventions in forest common pool resources. The visual power of PGIS can not be over emphasised (McCall, 2003) and, although it requires time and resources, it also provides a foundation to add more information as it becomes available. It is however essential that it is used responsibly with clear communicate regarding what and who it represents, when and why (Rambaldi et al, 2009). Maps will always be powerful, but can be applied towards achieving wider equity based objective in the hands of skilled facilitators and practitioner. In this regard the visual impact of GIS to demonstrate the complexities of socio-ecological systems has the potential to challenge the position of simplistic models and universal design principles for common property regimes with policy.

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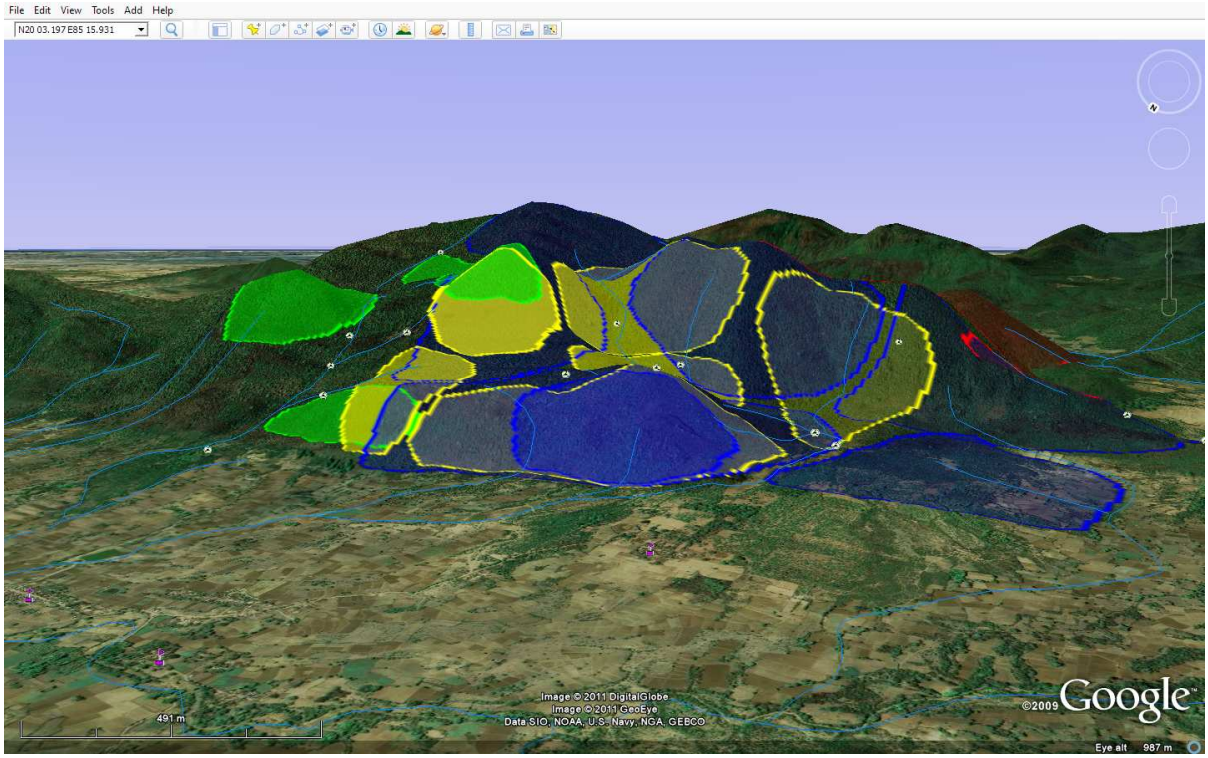
Appendix:

Appendix 7.1: An example of Google Earth images used in the Community mapping process



Appendix 7.2: Household Survey used in the study

HOUSEHOLD SURVEY

Community	
Household Number	

A. **Household Profile:**

(1) Tribe of head	
(2) Caste of head	

ID No.	Age (Years) (5)	Sex (M–1, F– 2) (6	Relationship to head (code) (7)	Livelihoods (cash and in kind)		
				Primary	Secondary	Other
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						

Codes & Notes: by Column

7 (Relationship to head): self-1, spouse of head-2, married child-3, spouse of married child-4, unmarried child-5, grandchild-6, father/mother/father-in-law/mother-in-law-7, brother/sister/brother-in-law/sister-in-law/other relatives-8, servant/employee/other non-relatives

8 Livelihoods

(1) _____Farm cultivation

(2) _____Casual labour (farm and non-farm)
(3) _____Salaried employment
(4) _____Petty business/trade/manufacturing
(5) _____Collection/foraging for self-consumption
(6) _____Collections for sale
(7) _____Other

C Private Landholdings:

Type (10)	Area (11)	Irrigated (12)

D Collection of Forest Natural Resources

What Natural Resource (13)	Who Collects (M-1, F-2) (14)	When Month (1-12) Season (days) (15) Months		Why (Household consumption - 1 Sale - 2, Both - 3) (16)	Where is it collected (Revenue -1, Community protected Reserve-2, Other community areas-3) (18)

E. Hydrological services:

Type **(19)**	**Facility (dam-1, pump-2, natural-3)** **(20)**	**Location (Revenue -1, Community Protected Reserve-2, Other community areas-3)** **(21)**	**Source** **(22)**
Drinking water			
Washing			
Irrigation			
Cattle drink			

F. Cattle grazing

Number of cattle (23)	**Where they graze (Revenue-1, Community protected Reserve-2, Other community area-3) (24)**

G. Other benefits from the forest (cultural, tranquillity, religious sites, biodiversity)

What (25) (picnic, rest, pray, festival, peace etc)	**Name (26)**	**Where (27)**

H. Boundaries

(28)	**Do you know the boundaries? (29)**	**How are they marked? (30)**
Formal boundaries (Revenue)		
Formal (Reserve)		
Customary (Protected areas)		

I. Participation in Management activities

What	**Who**	**Participation attend meetings/ go on patrol)**
Committee		
Patrolling		

Appendix 7.3: Form used in research to obtain consent for activities and facilitate understanding about the research topic and expectations

Would you like to help me with my research?

My name is Esther Carmen and I am an MSc (Masters of Science) student from the University of East Anglia in the UK.

My research is looking at how local people use and interact with spaces within forest to collect forest goods and visit. I want to do this to understand the different reasons that

different people come to this forest. This will be include the creation of maps of the forest which will help with my studies but also provide information to the local communities who visit the forest. I will be asking local people to draw the landscape and which forest goods they collect where. I will also visit the forest and visit some of your local landmarks and sites which are important in the forest. This will help me to create an accurate map of the forest area used by the neighbouring communities Dhengjhari, Lunisihi, Madrakota and Jagannath Prasad. To help with this and to understand who collects which goods and where I will also be conducting brief household surveys.

If you agree to take part in this research I would like you to tell me about which natural resources are important to you and show me where you collect them on a sketch map.

To help us with this there will be a local research assistant who speaks both Hindi and English. Their role will be to translate to assist me in facilitating the activities. If at any time you can not or do not want to answer a question or provide information you may choose not to and we can stop at any time you wish. If you would like a copy of any maps and information I will be very happy to make sure you have a copy. This will allow you to also use this information.

The information you provide as an individual will remain confidential and will not be shown to anyone. I will use it with all the other data from the other individuals to create general maps of the surrounding area showing the different resources and where people collect these goods. Therefore you will not be identifiable in this research or the specific areas your household uses to collect forest goods.

If you feel that you no longer want to take part in the research or if you do not want any or all of the information you have given me to be used, then you can tell me at any time.

QUESTIONS AND CONTACT DETAILS
Should you have any questions now or at any other time about this research, and your participation please feel free to ask. I can be contacted at (insert local and international phone numbers). You are also welcome to call my supervisor Dr Oliver Springate-Baginski who can verify who I am and the nature of my work in India.

AGREEMENT TO PARTICIPATE AND HAVE MAPS DIGITALLY RECORDED
Respondent's Copy

The research information was presented in written form and read by/to me.
Anything I did not understand was explained and all my questions were answered.
I understand I can withdraw my participation at any time and any or all of the information which I give before the 1st August 2011.

I, …….. agree/disagree to participate in the study and agree/disagree to have any maps which I help produce digitally recorded.

Signature/Mark of Respondent:
Date:

Signature of Researcher/Research Assistant:
Date:

……

AGREEMENT TO PARTICIPATE AND HAVE MAPS DIGITALLY RECORDED
Researcher's Copy

The research information was presented in written form and read by/to me.
Anything I did not understand was explained and all my questions were answered.
I understand I can withdraw my participation at any time and any or all of the information which I give before the 1st of September 2011.
I, …….. agree/disagree to participate in the study and agree/disagree to have any maps which I help produce digitally recorded.

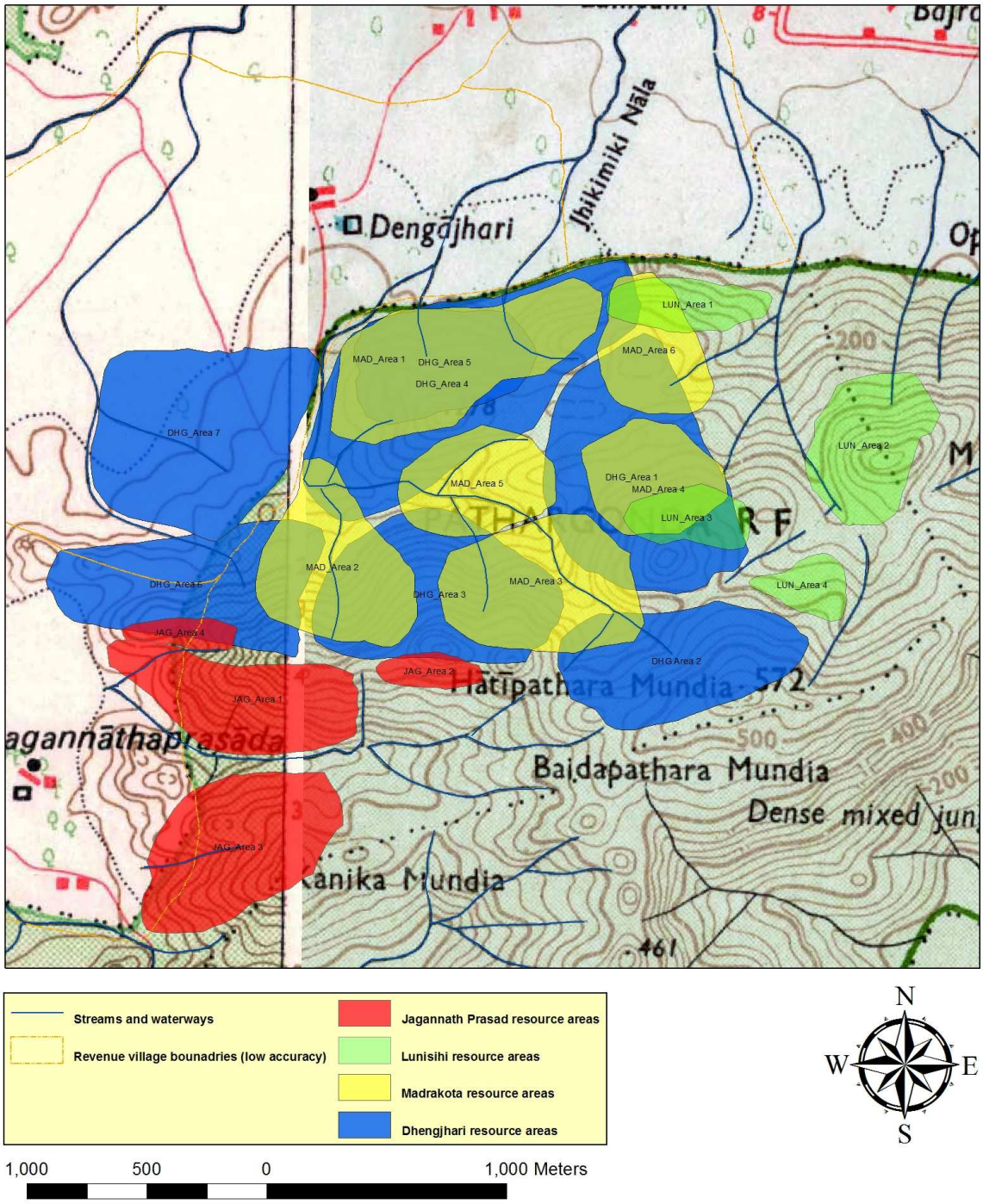
Signature/Mark of Respondent:
Date:

Signature of Researcher/Research assistant:
Date:

Appendix 7.4 Table of household data and spatial data links

Id	Community	label	Goods	ST	ST F	ST M	SC	SC F	SC M	G	G F	GM
0	JAGG	JAG_Area 1	Mushrooms, Siali, Medicinal plants, Sal, Tubers, Bitter gound, Madhamalati flowers, Honey, Karanja.	Y	Y	Y	N/A	N/A	N/A	N/A	N/A	N/A
1	JAGG	JAG_Area 4	Hillbroom	Y	Y	N	N/A	N/A	N/A	N/A	N/A	N/A
2	JAGG	JAG_Area 3	Medicinal plants, Tubers, Bitter gound, Krankada, Honey, Sal, Siali, Kendu, Mahua flowers, Mahua seeds, Karanja.	Y	Y	Y	N/A	N/A	N/A	N/A	N/A	N/A
3	JAGG	JAG_Area 2	Bamboo, Timber (low cost)	Y	N	Y	N/A	N/A	N/A	N/A	N/A	N/A
4	DHG	DHG_Area 6	Firewood, Tubers	Y	Y	N	Y	Y	Y	N/A	N/A	N/A
5	DHG	DHG_Area 3	Siali, Bamboo (Tinia), Medicinal plants, Honey, Timber.	Y	Y	Y	Y	Y	Y	N/A	N/A	N/A

6	DHG	DHG Area 2	Siali, Bamboo	Y	Y	Y	Y	Y	Y	N/A	N/A	N/A
7	DHG	DHG_Area 1	Tuber Bamboo (Kanta) firewood mushroom siali honey	Y	Y	Y	Y	Y	Y	N/A	N/A	N/A
8	DHG	DHG_Area 5	Honey, Tubers.	Y	Y	Y	Y	Y	Y	N/A	N/A	N/A
9	DHG	DHG_Area 4	Firewood, Siali, Siali binding bark	Y	Y	Y	Y	Y	Y	N/A	N/A	N/A
10	DHG	DHG_Area 7	Sal, Kendu, Mahua flowers and seeds	Y	Y	N	Y	Y	N	N/A	N/A	N/A
11	LUN	LUN_Area 1	Firewood	N/A	N/A	N/A	Y	N	Y	Y	N	Y
12	LUN	LUN_Area 2	Bamboo	N/A	N/A	N/A	Y	N	Y	Y	N	Y
13	LUN	LUN_Area 4	Bamboo	N/A	N/A	N/A	Y	N	Y	Y	N	Y
14	LUN	LUN_Area 3	Bamboo	N/A	N/A	N/A	Y	N	Y	Y	N	Y
15	MAD	MAD_Area 6	Firewood, Mushrooms.	Y	Y	N	Y	Y	Y	Y	N	Y
16	MAD	MAD_Area 1	Tubers	Y	Y	N	Y	Y	Y	N	N	N
17	MAD	MAD_Area 5	Poles and house timber	N	N	N	Y	N	Y	Y	N	Y
18	MAD	MAD_Area 3	Bamboo	N	N	N	Y	N	Y	Y	N	Y
19	MAD	MAD_Area 2	Firewood	Y	Y	N	Y	Y	Y	Y	N	Y
20	MAD	MAD_Area 4	Medicinal plants, Bamboo	Y	Y	N	Y	N	Y	Y	N	Y



Appendix 7.5: Map showing labels of natural resource area used for linking spatial data with socio-ecological information gathered in household surveys.