Agrarian Diagnosis
Role played by dairy farming in the agriculture in Ekangar Sarai block, Bihar, India

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Internship:

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Foreword

The results presented in the following report are derived from a four and a half fieldwork. The points of view exposed are those of the authors. Farmers' opinions are not mentioned in the present reports. We apologize in advance for the mistakes and misunderstanding that we have done.

The maps presented in this document do not guarantee the accuracy of recognized India borders.

Abstract

The present report is an agrarian diagnosis achieve in the south of Patna. It allows explaining farm diversities, through the understanding of landscape and the history of the study area.

The Green and the White Revolution have changed the agriculture in Bihar. Nevertheless, they are not the only explanation of farm diversities. Landscape and social organisation have their share of responsibility. For example, access to water is different through the block and in a village. It depends on the groundwater level and the wealth of the farmers. This access to water influences growing of cropping systems. Indeed some crops, such as paddy, wheat and vegetable, need lots of water.

Vegetables are one way to intensify the production and increase the growth product. Another way could be the dairy sector which has been developed by Sudha cooperative since 2003. This dairy cooperative has created new markets and new perspectives. However, these opportunities appear unreachable for the poorest people. Lack of financials means, lack of access to water and access to land are the main reasons. Some ideas are studied in order to submit new dynamics and opportunities.

Key words: Bihar, Agrarian diagnosis, Green Revolution, White Revolution, Sudha cooperative, access to water.

Units and devices

Table 1: Length conversion

	Inches	Feet	Metre
1 inch			
1foot	12		0.3
1 metre	39.4	3.28	

Table 2: Lands conversion

	Katthas	Bighas	Acres	Hectares
1 kattha		0.05	0.03	0.0125
1 bigha	20		0.625	0.25
1 acre	32	1.6		0.4
1 hectare	80	4	2.5	

Table 3: weight equivalent

1 mound	40 kg
1 tonne	100 kg

Table 4: Exchange rate between January and May 2015

1 euro	70 INR
10 000 INR	142 euros

Acronym and abbreviation

BPL: Below Poverty Line

CS: Cropping System

FI: Farm Income

GP: Gross Product

GVA: Gross Value Added

Ha: Hectare

IC: Intermediate Consumption

INR: Indian rupees

Kg: Kilogramme

Km: Kilometre

L: Litre

LS: Livestock Rearing System

NAV: Net Value Added

PS: Production System

PACS: Primary Agricultural Cooperative Society

Rs: Indian rupees

Ø: Fallow

Contents

Introduction

Nowadays, India has achieved its goal. It becomes self-sufficient in milk and the largest producer of the world (16% of the world production)[1]. If we look at the size of the population which exceed 1,2 milliard people, and the consumption per capita of 41,2kg of milk and 3,6k of butter per year[2] in average, this is a unique feat. Moreover half of this production is self-consumed by Indian families[3]. In order to reach this goal, India implements the Operation Flood Programme in 1970[4]. This programme was based on cooperative systems modelled by Anand Milk United Limited (AMUL). Today, in each state one cooperative is established. However, milk production is not safe and India should cope with new challenges: population increase, decline of farming interest…

Bihar, which was dependent on the other states for milk production, has become independent since 2012. Today Bihar state is one of the ten bigger Indian state producers of milk[5]. In Bihar, the cooperative model has been implanted and is characterized by Sudha. This cooperative is also present in Ekangar Sarai block.

The study in Ekangar Sarai block, which is presented in this report, belongs to two projects. One is a CGIAR Research Program on Livestock and Fish[6], designed to develop smallholder dairy value chain. The second includes other studies like this, in other districts and states, in order to understand and identify dairy production dynamics at a district, state, and national scale.

The study is based on a systemic approach, the agrarian diagnosis, which has different level of analysis. This method takes care about all the aspects of agriculture and allows understanding the complexity, diversity and dynamics of the landscape complexity. All the elements of history, landscape, sociology and economy are connected.

This report is the culmination of four and half months spent on the field in Ekangar Sarai block. In order to understand the place of livestock and the diversity of farms we will talk about, the place of Bihar state in the country, the landscape of Ekangar Sarai block, the history of the study area. Then we will focus on farm diversities and their economic outcomes. During all our report, we will connect all these elements. Lastly when we will understand all problematic and perspectives we will discuss about the future dynamics.

[1] http://www.fao.org/agriculture/dairy-gateway/milk-production/en/#.VZS7MPntmko
[2] http://www.planetoscope.com
[3] http://www.fao.org/agriculture/dairy-gateway/the-dairy-chain/markets-and-trade/en/#.VZS7DPntmko
[4] http://www.nddb.org/
[5] The Economic Times, *Bihar becoming major milk producer,* July, 10th 2011 : http://articles.economictimes.indiatimes.com/2011-07-10/news/29758152_1_milk-procurement-lakh-litre-milk-production
[6] http://livestockfish.cgiar.org/focus/india/

Presentation of India

1.1.The Indian mosaic

India is an Asian country which has a geographical area of 3 287 590 square kilometres. It is bounded by the Indian Ocean in the South and by the Himalaya mountains in the North. This country has a common border with Pakistan on the West, Bhutan and Bangladesh on the East, and Nepal and China in the North. Some of these borders are more or less pacific.

This large country offers a lot of ecosystems. There are three main geographical areas. In the North, the Himalaya Mountains culminate until 8000m over the sea level and its valleys are cultivated. In South, the basaltic Deccan traps are crossed by large irrigated valleys. Between these two areas, there is the Indo-Gangetic alluvial plain, which is irrigated and fertile (figure 1).

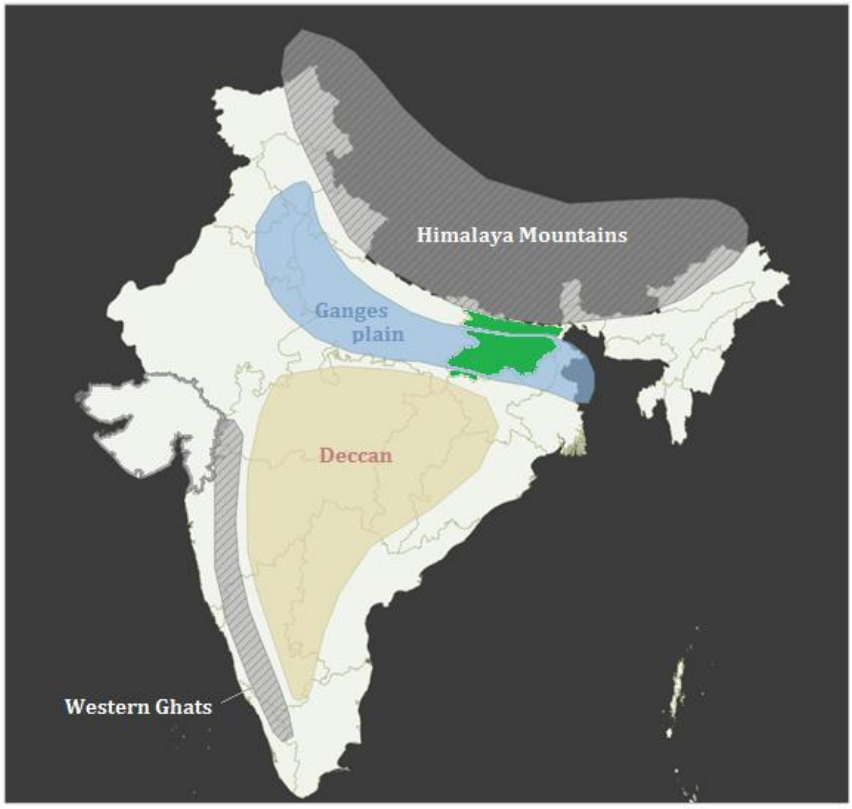


Figure 1: Relief of India (Hugo LEHOUX 2014)

India is seasonally crossed by monsoon rains, which are important for agriculture. The trade winds coming to the South-West are moved to the North by the Inter-Tropical Convergence Zone (ITCZ). Himalayan mountains block this air which goes up and becomes cold. This phenomenon charges the air in water. It's the monsoon. Winds arrive in West India at the end of May and in East at the beginning of July (figure 2). However rainfalls are unequal in the different parts of the country. Some areas, such as Himalaya or Western Ghats, record rainfalls of 2000mm/year. Other parts, like central Deccan, receive between 500 and 1000mm/year. Moreover some parts are deserts like in Rajasthan (less than 500mm/year).

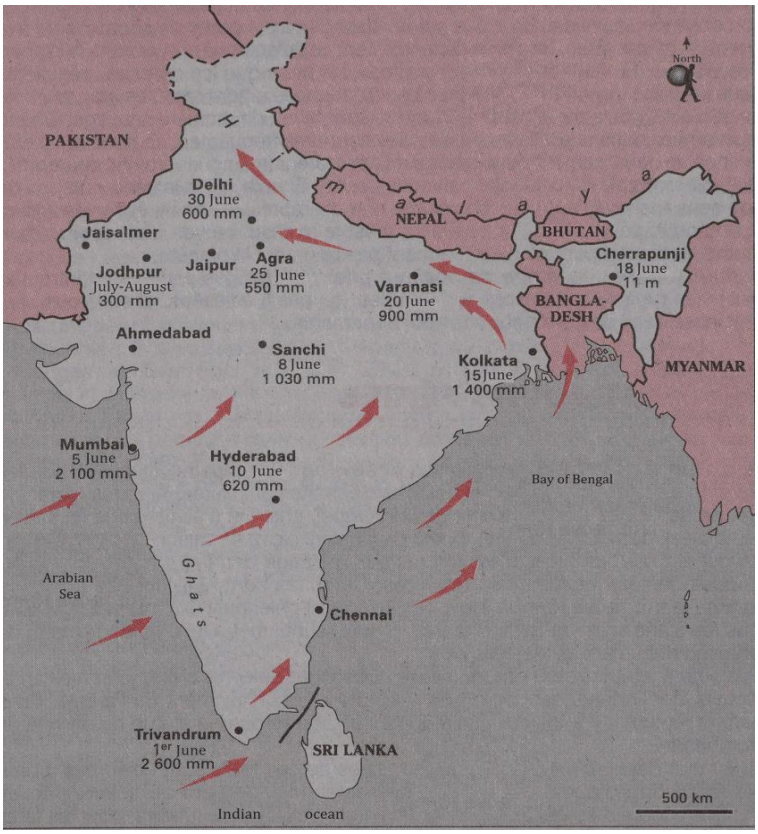
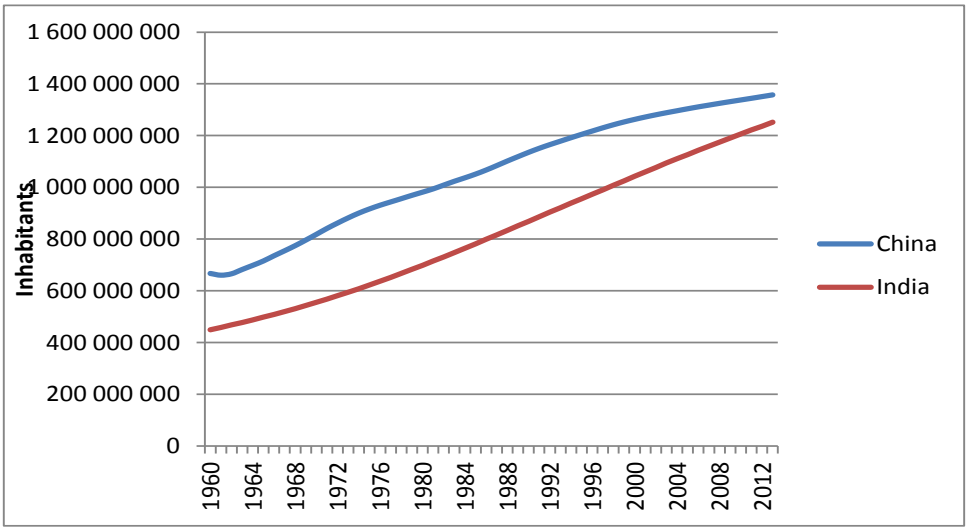


Figure 2: monsoon scheme

According to the United Nations, Indian population of about 1.25 milliards[7] (940 women for 1 000men[8]), could become the most important of the world in 2028 (graph 1). With 381 habitants per square kilometres, the subcontinent is overcrowded. The most populous areas are localised in the Ganges valley and on coasts. Some states in Ganges valley reach to 1100 habitants per square kilometres[9]. The population is mainly rural; only about 32% people live in urban areas[10].



Graph 1 : demographic growth of India and China

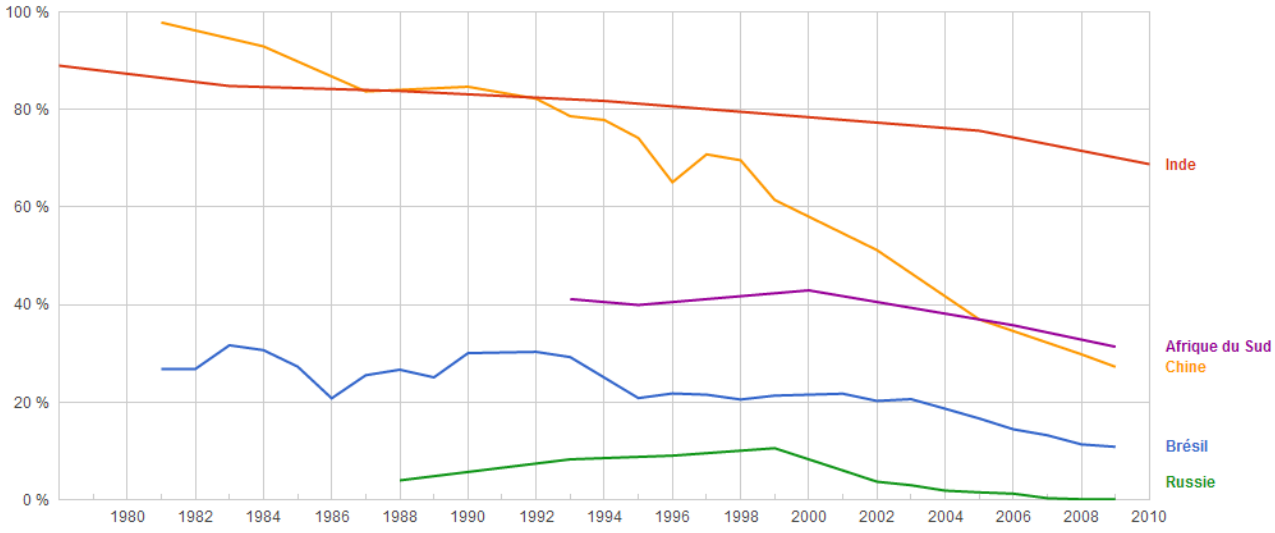
[7] World Bank
[8] Census of India 2011
[9] Census of India 2011
[10] World bank

India is a mosaic of languages and religions. If we add English, twenty-three official languages are recorded. The Hindi is the national language. Other languages are in relation to geographical positions and religions. 80,5% of population is Hindu, the other main religions are Islam (14%), Christianity (2%), Sikhism (2%), Buddhism (0.8%) and Jainism (0.4%). Even if it has been a laic state since 1947, for many years, these different religions are conflicted. Moreover, in the North, customs have a strong place in way of life.

1.2.Looking for the balance

India belongs to the BRICS (Brazil, Russia, India, China and South Africa) which are emergent countries. In 2014, this parliamentary democracy became the 4th largest economy in the world expressed in purchasing power parity terms. Economy of India is leaded by dynamic states. These states are preferentially localised in South or are colonial territories. The subcontinent is also the 4th agricultural power (World Bank, 2015). Agriculture represents around 18% of the gross domestic product (GDP)[11] and employed 60% of the population.

At the opposite the four BIMARU (Bihar, Madhya Pradesh, Rajasthan and Uttar Pradesh), which means ill in Hindi, represent more than 50% of poor population of India. It is the contrast presented in India. According to the World Bank, 31% of the population lives below the poverty line (62Rs) (graph 2).



Graph 2 : Percentage of population living with less than 2US$ PPA belong BRICS (World Bank, 2015)

In order to help poor people, India government has created the Below Poverty Line Card (BPL Card). Thanks to this card, people can purchase essential products below the market price. In some states, more than 30% of the population has this card (figure 3).

[11] World Bank

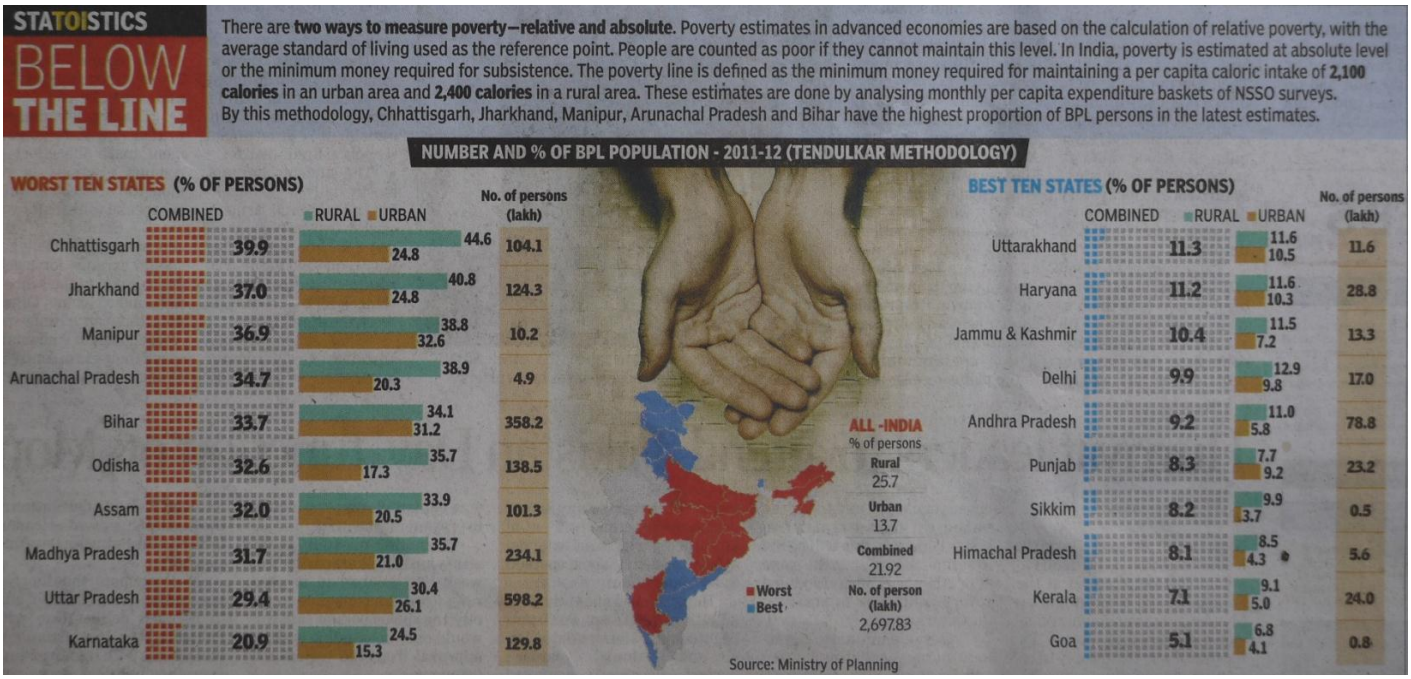


Figure 3 : Number and percentage of BBL population in 2011-2012 (The Times of India, March 21th 2015)

The diversity of wealth between states provokes migration of poor and qualified people toward rich cities. Poor people wish to find better life conditions and qualified people hope to find a job. The result is a disaster. On one hand in Mumbai, 1 million poor people live in shanty houses. On the other hand, there is a lack of engineers in poor states.

1.3.The limit of social organisation

Since 1600 years BC and beginning of *Aryens* history, Indian society is organised in castes. According to traditions, they are basis for Hindu community. They determine social position and can have an impact on professional and personal life.

In a religious Hindu text, the social groups, also named *varnas*, are sprung from a Hindu deity, who created the Indian society. Four *varnas* were created from different parts of his body. The *Brahmans* (religious) were born from his mouth, the *kshatriyas* (warriors) from his arms, the *vaishyas* (sellers, farmers and artisans) from his thighs, and the *sudras* (servitors) from his feet. Rest of population who has not *varnas*, are named *dalits* and *adivasi*. *Adivasis'* ancestors are most of the time tribal population present on the territory before *Aryens* came in this country. Even if these two groups are the more numerous, they are rejected by the society. The four varnas are sub-divided into *jatis*. These *jatis* are community which are sometimes linked to an activity.

Since 1950, in order to tackle inequalities, Indian government has created a national castes classification, *constitution scheduled class order*. This classification is contrary to the government's ambition to delete the caste system. It allows rejected people to climb social ladders. As a result, castes were renamed. The *Brahmans* and *kshatriyas* became *forward castes* (FC) (*open classes* or *upper castes*). *Backward classes* (BC) is used to name the *vaishyas and sudras*. *Scheduled castes* (SC) and *scheduled tribes* (ST) group the *dalits*. Some places in government and universities are reserved for disfavoured people.

Nowadays, the castes are always important in the life of Indian people. In some sub-continent's parts, villages are divided in two parts. In one part forward castes, backward classes and

scheduled castes are living, and in other part Scheduled tribes and Muslims people. Moreover, even if it is forbidden, arranged weddings are still organised. In few area crops' implantation depend of the castes. For example people do not seed vegetable because they do not belong to the *mahtos* castes.

Below, some castes met during our internship are described. In this part we speak only about the castes that we have some information.

- *Kurmi*: They belong to the backward classes. Their name would mean ploughman, this describe them as farmers. In our study, they are presented like instructed people who are most of the time owner of lands. The mahto seem to be a subdivision of the Kurmi. They are specialised in vegetable crops.
- *Yadav*: Belonging to the other backward classes, they breed bovine (cattle and buffalo). They kept some land after the Zamindari system abolition. Today sometimes they are tractor driver.
- *Rajput*: belonging to the forward castes they had links with *Zamindars*. They bought some lands after the Zamindari system was abolished.
- *Kumhar*: belonging to scheduled castes they were workers used by owners to cultivate lands.
- *Gareri*: they are shepherd, from generation to generation.

1.4.Problematic

This presentation provides an overview of the diversity of farms. In order to study past and future development actions, we need to understand the link between all the components which impact farmers' choices. During this report we will try to answer to these questions:

- How farmers adapt their practices to natural constraints (climatic, topographic, economic and social)? How do they renew fertility and protect their crops?
- What are the impacts of governmental actions (land reform, green revolution, white revolution)?
- How can we explain the differences and links between farms?
- Why for twenty years have we seen lots of rich and poor Bihari people migrating?

2. Methodology

2.1.Agrarian diagnosis face to agriculture complexity

Face to the complexity of these questions, it is necessary to understand all agrarian dynamics, diversity of farms and their interactions, in order to have a sight about perspectives. This allows analysing the interests of farmers and the difficulties they face. Thus, it allows proposing actions leading farmers to contribute to the general interest, while bearing in mind their own interests.

The aim of this study is to discuss about development actions, past and future, of the Ekangar Sarai block. Agrarian diagnosis seems to be adapted to identify and characterize the main issue of a small agricultural region. Indeed, this method takes into account environmental, socioeconomic and technical aspects, and their relationships. Studying only yields through technological and practical aspects could generate some misunderstandings. Moreover this method is focused on a large number of farmers and takes into consideration economically less influent farmers and powerful farmers. Through the agrarian system concept we hope to be able to understand agriculture in all its complexity.

Firstly, we need to define the agrarian system. "It includes the exploitation and preservation techniques of one or several ecosystems, the social relations of production and exchange which created this system and developed it, and the economical and social aspects, especially the system of relative price, which determined modalities of its integration on world market" (Cochet, 2000).
The agrarian diagnosis is a systemic approach which requires different knowledge about agronomy, sociology and economy. The base of this methodology is the interaction of these three elements. This analysis, starting from general aspect to famer objectives, tries to understand diversity of landscape and agrarian practices. For this to happen, we admit that "farmers have good reasons to do what they do" (Jouve, 1992). Indeed, some obstacles (climate, soil composition, hydrometric, market elements, and social) are imposed on farmers and they have to avoid them or to adapt their systems.

2.2.Agrarian diagnosis methodology

This methodology was taught by Claire Aubron in order to introduce our internship commanded by the ILRI. Moreover, this methodology was formalised by Isabelle Touzard and Nicolas Ferraton in the book *Comprendre l'agriculture familial* | *Diagnostic des systèmes de production* (edited by Quae).

2.2.1. Step 1: Landscape analysis

The first step is to analyse the landscape, in order to understand agroecological elements which have an impact on agrarian systems. To do so, it is necessary to walk through the block in order to define some areas which seem to be similar, and in order to note traces of the past such as former irrigation systems or unexploited areas. Then, we have to describe them precisely (topography, hydrology, types of soil (structure, texture...), vegetation, plot forms, type of animal and the percentage of each sex, building, equipment, etc). The description could be done at different scales (block, village, group of plots, plot...) in order to understand the complexity and links between different elements and to question different observations.

2.2.2. Step 2: Agrarian history analysis

Observations of the landscape during the first step raise several questions, especially about farm differentiation and the origin of the diversity. This differentiation can be linked with the past dynamics. Several questions emerge but two of these seem to be more important: Why some landless go in other state in order to find work and big farmers say: "Nowadays it is difficult to find workers"? Why some farmers walk one kilometre to cut grass to feed their cattle?

Natural phenomenon cannot explain all the observations. So we have to study agrarian history in order to understand the origin of these distinctions. Some interviews with older farmers allow defining stable period (the landscape do not evolve) or mutation phase. Face to different barriers, agriculture changes to adapt itself to the situation. Each interview was divided in two stages: first, we spook with farmers about the agrarian history of the Ekangar Sarai block and on secondly we discussed about evolutions of their exploitation. We tried to valid this information with historic documents. At the end of this step we have retraced agrarian history (practices, fertility management, weed management and employment of workforce) and the social organisation between different casts present in the block. Throughout this history we have approached and analysed the dynamic of evolutions (land divisions and distributions, workforce, finance power...).

2.2.3. Step 3: Characterization of production systems

Before starting this part, we need to define some notions. In order to analyse past and future evolutions of farms we use the concept of production system. It allows conceptualising exploitations in order to create a model which improves understanding. "A production system is a group of farms which use same resources (total lands size, equipment level and labour force) and which are placed in same socio-economic conditions and which practice same types of production" (Cochet, 2005). These production systems combine cropping systems and livestock rearing systems.

"A cropping system is a group of plots which are managed identically. Each cropping system is defined by its crops, their annual and inter-annual rotations, and practices applied to each crop including variety choice" (Sébilotte, 1977). Similarly, a livestock system is a horde of animals managed and fed identically.

The landscape and history analysis allow understanding the origin of differentiation between each farms. However we have to understand what the result is today. Therefore we use the notion of production system. We group similar farms together in order to create archetype. We describe each type by its cropping systems (rotation, management, varieties...), its livestock rearing systems (breed, number, alimentation...) and links between these systems. We included in this study the annual calendar, input, output, material, equipment and other non-farm work which could increase incomes. After this we can analyse economic aspects of each type.

2.2.4. Step 4: Economical analysis

After studying technical aspects, we analyse economic points in order to quantify different incomes of each farm. This analyse could provide some justifications for farmers' choices: which crops are more profitable in which case? Why some farmers prefer to rent some plots and others to be daily labourer? Why some farmers have some cattle even if they are landless?

2.2.4.1. Gross product (GP)

For each cropping and livestock rearing system, we calculate the gross product, which is the sum of sales (quantity produced x selling price) and value of self-consumed products (self consumed quantity x market price).

2.2.4.2. Intermediate consumptions (IC)

Intermediate consumptions are all the products and services used during a cycle, for all cropping or livestock systems. They include inputs costs (seeds, fertilizer, pesticides, etc.), energy consumption (oil or electricity), feed and reproduction costs of animals, etc.

2.2.4.3. Gross value added (GVA)

The gross value added represents the wealth generated by farmers for a cropping or livestock system. This value is obtained by subtracting intermediate consumptions from the gross product.

$$GVA = GP - IC$$

This value allows a comparison between economic performances of different cropping or livestock system. Then, we can analyse these values according to mobilized land areas (GVA/ha) or per time unit (GVA/working day). These values could explain farmers' choices. Some farmers opt for crops which offer high gross value added per hectare and others, preferring to free up working time, choose to maximise the added value per working day.

The rest of economic analysis is assessed from the perspective of production systems (farm scale).

2.2.4.4. Depreciation (Dep)

Depreciations are amount distribution of property (equipment, building, etc.) over the duration of use.

2.2.4.5. Net added value (NAV)

To calculate the net value added (NVA), the sum of all depreciations is deducted from GVA at farm scale:

$$NVA = \Sigma(GVA) - Dep.$$

NVA is an estimation of the wealth created in production systems. We do not assess NVA from the perspective of cropping of livestock system because it is difficult to assign equipment or building degradation to a particular system. Other indicators such as NVA/ha or NVA/worker could be used in order to compare economic and socio-technical performance.

2.2.4.6. Farm income (FI)

In order to obtain the real farmer's remuneration and the redistribution of the wealth created, we have to substrate, from the NAV, workers salary, interests on loans, taxes, land rental costs ; and to add subsidies and land rents.

$$FI = NAV - (salaries + taxes + interests + land\ rental\ costs) + subsidies + land\ rents$$

This farm income could be compared to reference values, such as poverty line or survival threshold. The comparison of economic performance of all production systems allows an identification of obstacles to the development of these farms, and impacts on one another. Development actions may be proposed to benefit to the majority, with regard to the whole of agrarian system.

3. Presentation of study area

3.1. The state of Bihar

The state of Bihar is located in North-East of India, at the foot of the Himalayas (figure 4). The proximity with the highest mountain range of the world makes it one of its main watersheds. Rainwater running-off along these mountains feed the Ganges River, the most sacred river of the country. This river is one of the main factors that have shaped the area, which is an alluvial plain.

Figure 4 : India and the state of Bihar

Bihar has traditionally influence the political and religious history of India. Several religions, such as Buddhism and Jainism were born in this state. One of the world's oldest universities was also built in the 5th century. We cannot minimise the importance of Patna, Bihar state's capital and centre of power.

This state, having 104 million inhabitants, is the 3rd most populous in India[12]. Alone, it accounted 8% of the total Indian population. Its relatively small size (94 163km^2) makes it one of the most densely populated area of the world (1100 inhabitants per square kilometre in average). The state of Bihar, which has the lowest literacy rate[13], the highest number of people living under the poverty line and the lower income per capita, is one of the poorest regions of India. This state is mainly rural with, in 2015, only 11% of its population living in agglomerations[14]. Most of the population is dependent on agriculture for a living.

[12] Census of India 2011
[13] Census of India 2011 http://www.census2011.co.in/literacy.php
[14] Census of India 2011

3.2.Location of the Ekangar Sarai block

The International Livestock Research Institute, sleeping partner of the study, is involved in a CGIAR Research Program on Livestock and Fish. As part of this project, the institute wants to study the role of dairy production in the agriculture of Bihar. So it has been chosen to focus the study in two areas:

- The first area was the Ekangar Sarai block, located near the Ganges River (35km). It is in the west part of Nalanda district, 50km south of Patna. The block is bordered to the west by the Phalgu River, which is a rain fed river.
- The second area was the Bodhgaya block, in Gaya district. This area was chosen in order to analyse if having an urban area so close (the city of Gaya located at 13km from the block) could influence the agriculture and the demand for agricultural and dairy products. Moreover, this area is a little further away from the Ganges River, and it could be drier. This block is also crossed by the Phalgu River.

This report deals with the first study area: the Ekangar Sarai block, in Nalanda district (figure 5). This district takes a strong position in the state thanks to the Nalanda University or tourist places such as the city of Rajgir.

Covering a land area of 134km^2, the Ekangar Sarai block consists of 18 *panchayats* (sub-division of block). About one hundred seventy thousand people are living in this block, six thousands of whom live in Ekangar Sarai city, the main town[15].

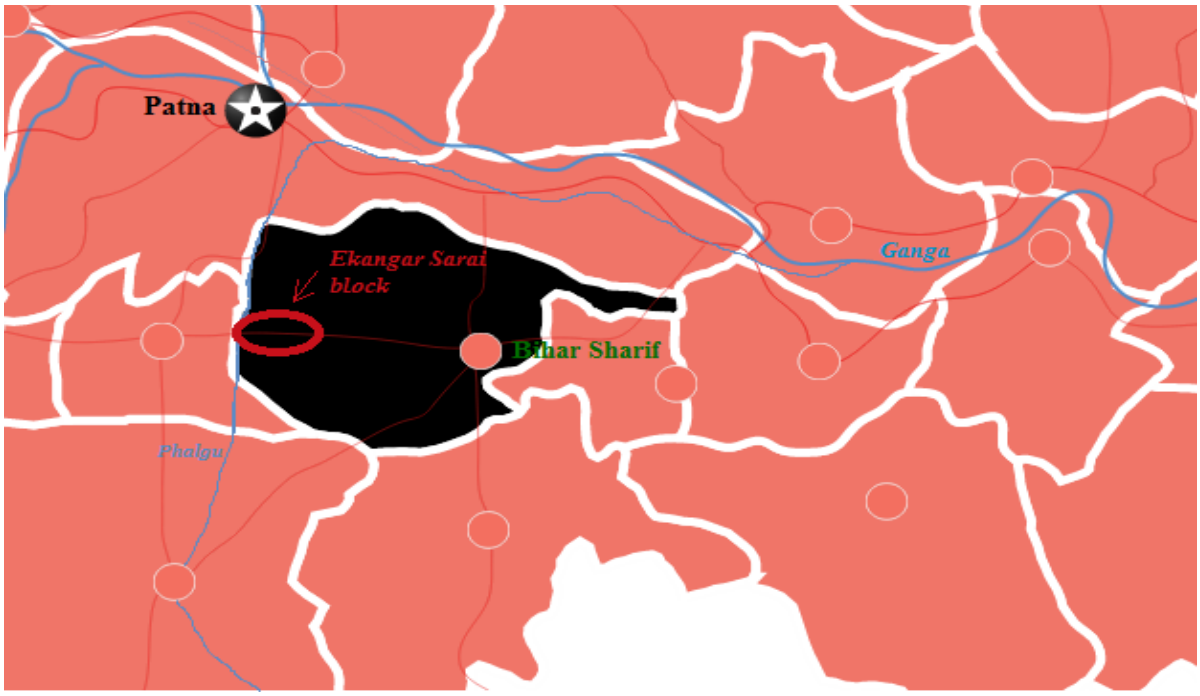


Figure 5 : Location of the Ekangar block

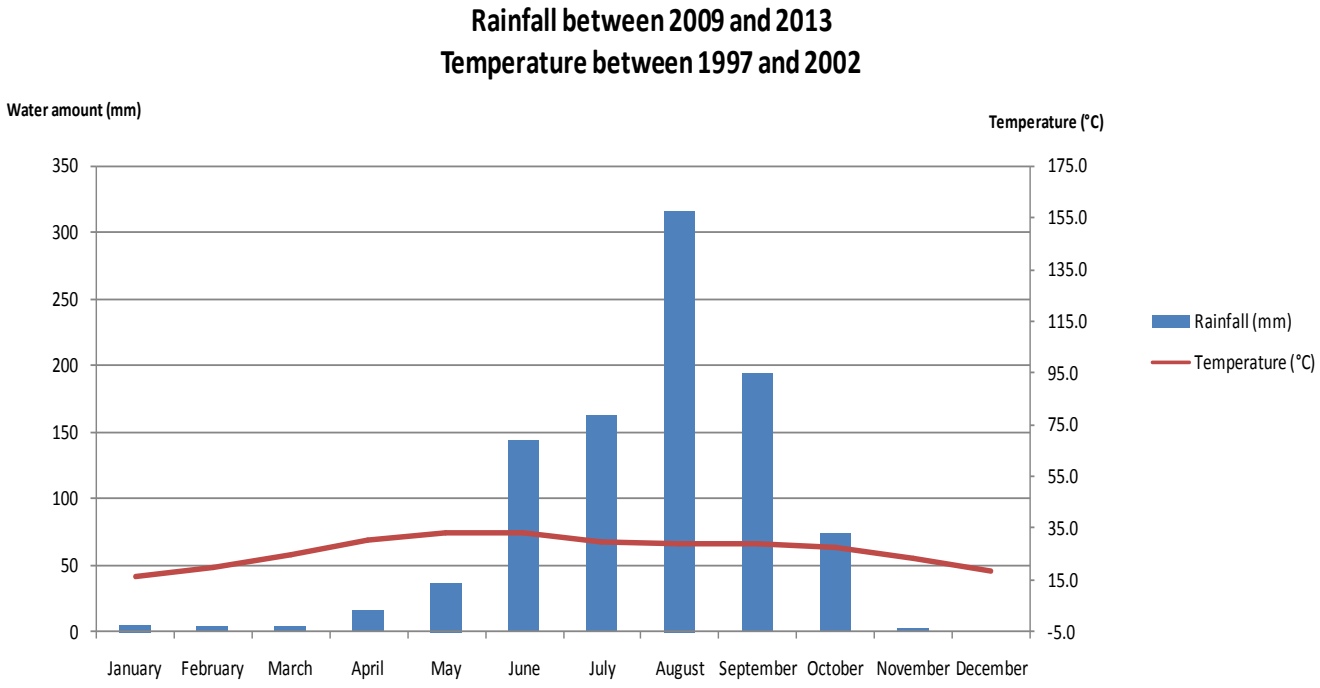
[15] Census of India 2011

3.3.Climate

The climate is subject to the monsoons. The year is divided in three seasons:

- Winter or *Rabi* season: during this colder season going from November to the end of February, temperatures range from 10 to 20°C. Rainfall is low, although it is increasing last 10 years.
- Summer: this warm and dry season goes to the end of May. The temperatures can reach to 45°C. Groundwater level decreases during this period.
- Monsoon or *Kharif* season: the rainy season is from June to October. 78% of the precipitation falls during this season. In Bihar Sharif, on average, it rains 1 000mm a year. The rains come in June and continue until September. The rest of the year is relatively dry. Moist air masses from the Bay of Bengal hit the Himalayan Mountains and fall on the Gangetic plain, for 4 months.

These three seasons are characterized by strong rainfall and temperature fluctuations. Temperature/rainfall data are presented in the diagram below (graph 3), which combine Nalanda district data. On the diagram, the temperature peaks are not taken into account, they are average daily temperatures.



Graph 3 : Temperature/rainfall data in Nalanda district

3.4.Limited infrastructures

As the whole Bihar, the Ekangar Sarai block is rural and infrastructures are limited (figure 6). The most developed villages are supplied with electricity since 1952. However, in 2015, some of them are still without power. The block is crossed by two national highways, one from east to west connecting Bihar Sharif to Jahnabad, the other from south to north, connecting Gaya to

Patna. From north to south, a railway line connects Patna to Islampur, through Ekangar Sarai. Villages are links with the main arteries by roads in poor condition. However, observations in the field have shown lots of road improvement activities and electric installations. Most of agricultural input stores are in Ekangar Sarai city, as well as the cold store allowing storage of potatoes.

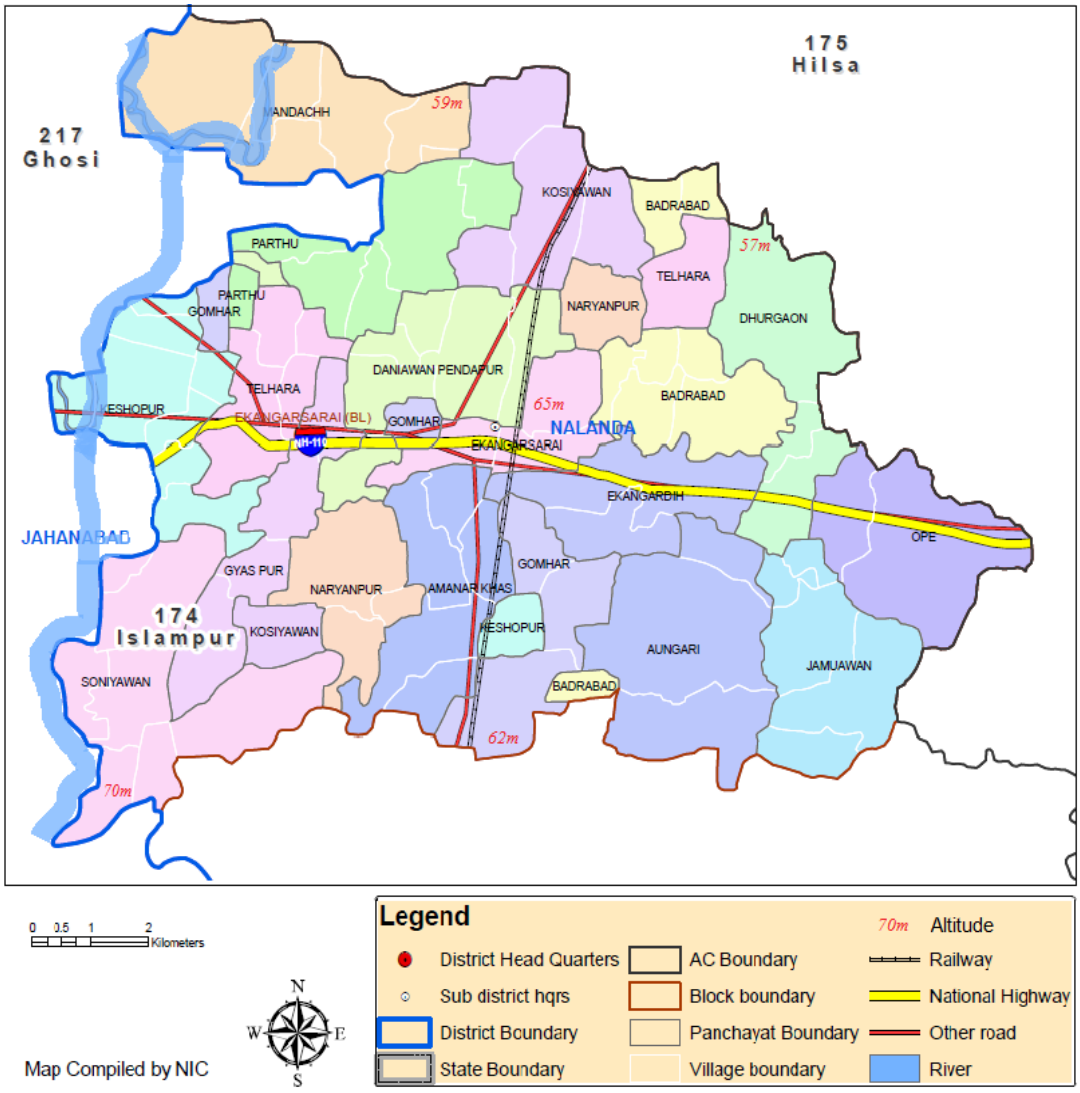


Figure 6 : Map of Ekangar Sarai block

4. Agroecologic zoning

4.1.Ecosystem and agro-ecological zoning

4.1.1. Ecosystem

4.1.1.1. Alluvial plains

Our study area is an alluvial plain with a low slope. It is the Ganga watershed. This river flows in an east-west direction. The figure below shows localisation of the two study areas (Ekangar Sarai and Bodhgaya block). Both are located in the valley slope inclined from south to north (figure 7). The relief in Ekangar Sarai block is less important than in the second block.

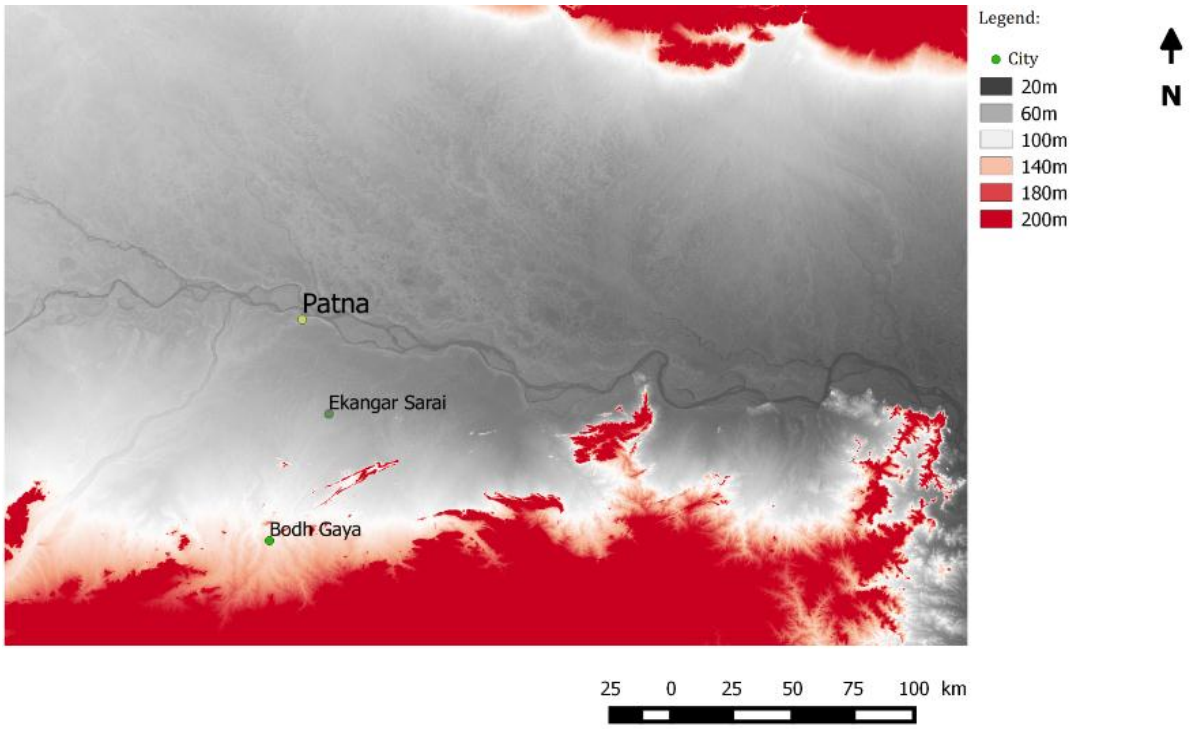


Figure 7 : Location of the two study areas

Other rivers, feeding the Ganges River and flowing from south to north, could change the relief. Ekangar Sarai block is crossed by two rivers. The temporary Phalgu River, mentioned above, is fed by storm water. During summer season, its water level decrease significantly, but some basins are still present (figure 8). Another river, which is also a rainfed river and is dry a part of the year, crosses the south-east of the block.

Figure 8 : The Phalgu River

In order to study more precisely the relief and the influence of these rivers (Ganga river and its tributaries), we will present three transects (figure 9). The first is oriented west to east, to analyse the impact of the Phalgu River on topography; the second is oriented north to south; and the latter from the southwest to the northeast, towards the Ganga River. These three transects pass through the town of Ekangar Sarai, in the middle of the block.

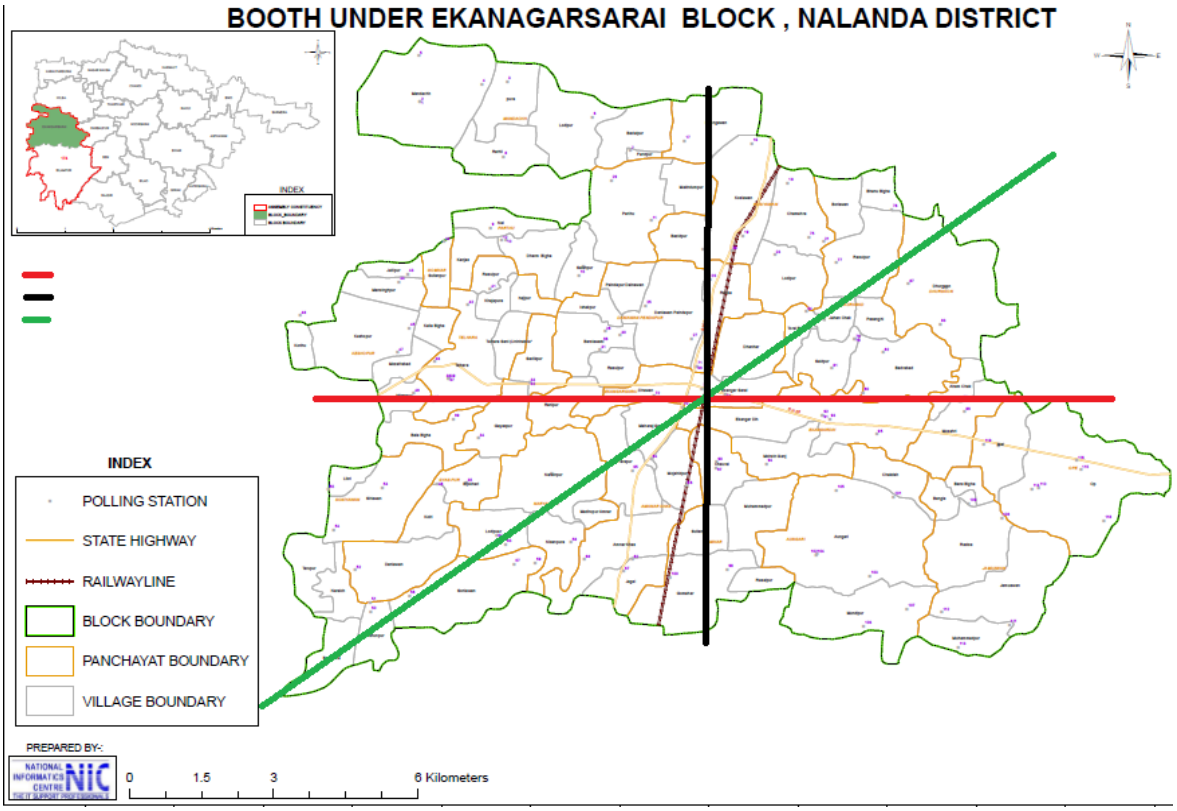


Figure 9 : Location of transects

We note a difference in altitude of 7m between the west and the east (figure 10). The high point is located in the western side of the block, near the Phalgu River. This river leads to the formation of a raised sandy bank. Between the westernmost of the transect and the raised city of Ekangar Sarai, we record some level fluctuations, with alternating high and low points. These topographic differences could be explained by the presence of small hills between these two points. After Ekangar Sarai, the slope is more constant due to the less number of reliefs.

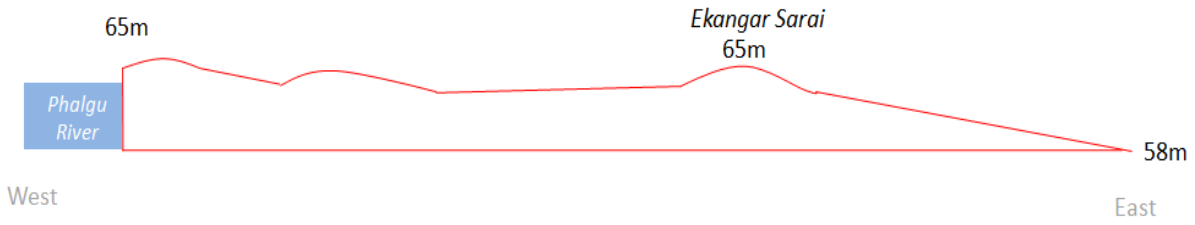


Figure 10 : Transect 1

As explained previously, the Ganges River, in the north seems to influence the topography of the block. The transect (figure 11) reflects a gradient of 7m between the south, higher, and the north. As the first transect, this one shows that the town of Ekangar Sarai is located in a high point, and that the slope is not constant but there are many low and high points.

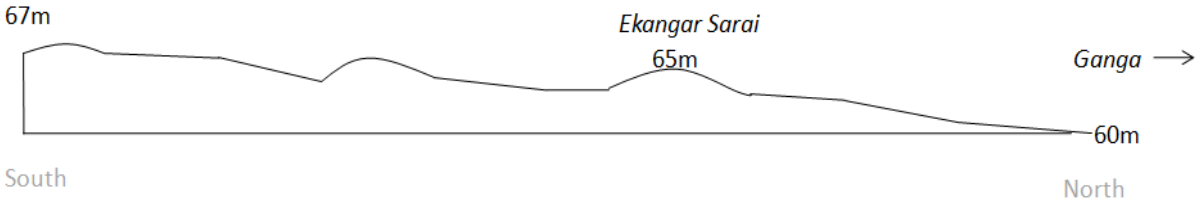


Figure 11 : Transect 2

The last transect follows the maximal height differences (figure 12). Between the southwest and the northeast of the block, the height difference is 13m. The slope becomes more important in the north-east of Ekangar Sarai.

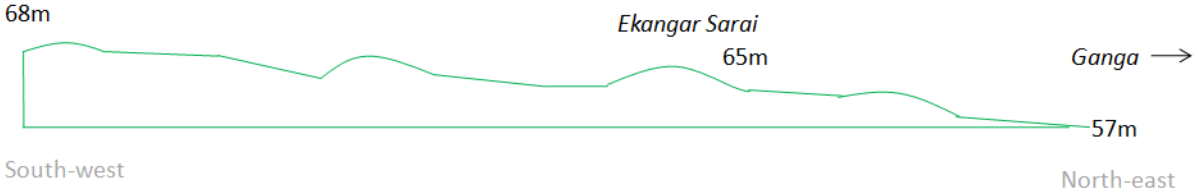


Figure 12 : Transect 3

The figure below confirms that the block slopes broadly from the south-west to the north-east (figure 13). However it is dotted with low and high points.

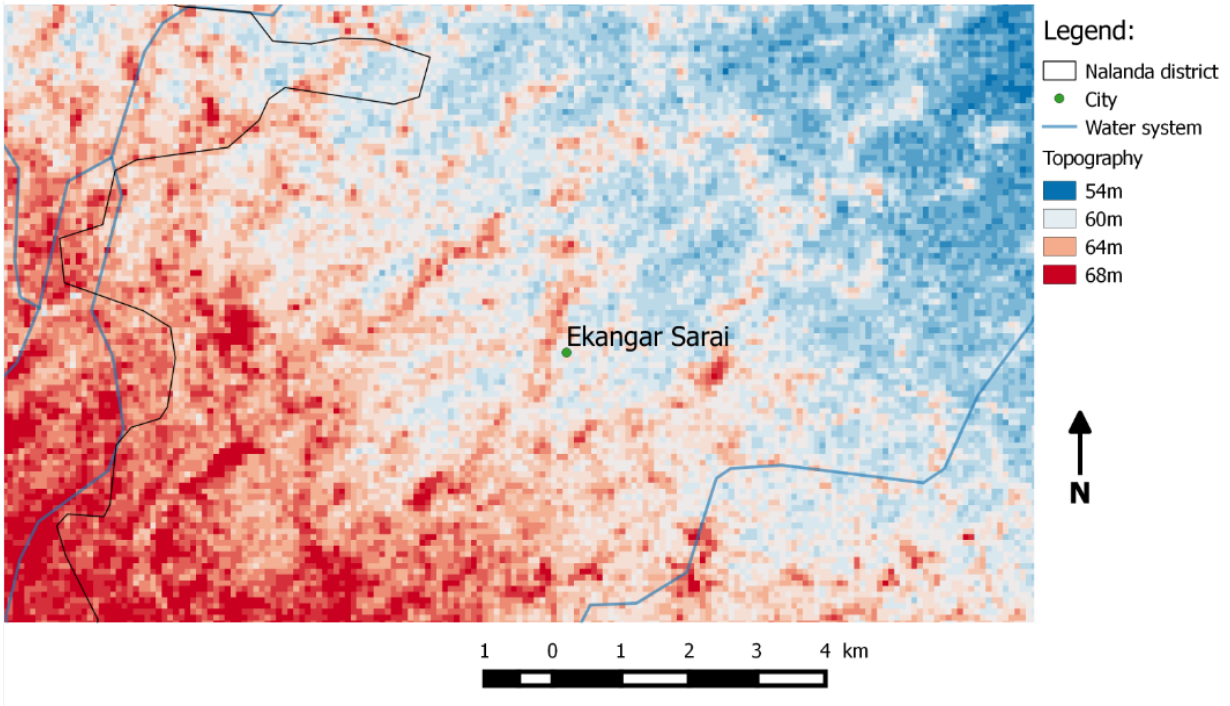


Figure 13 : Topography of Ekangar Sarai block

The block is composed of sandy soils (20%) and clay-loam soils (80%)[16]. Sandy soils form a 2 km strip along the river. Most of the soil has a neutral pH. However, we have noticed a more basic soil close to the river. We observed 90 to 95% of lands would be cultivated.

4.1.1.2. Rivers influencing the level of groundwater

In contrast with the topography which is influenced by the Ganges plain, the level of groundwater is mainly affected by the Phalgu River. The map below (figure 14), based on interviews with farmers, shows the distribution of this level. Except for a south-eastern area near the village of Aungari, the level of groundwater decreases away from the river. We think that the dried river could influence the high level of water in the south-east of the block. The difference of the level of groundwater between the beginning and the end of rainy season seems to be 20 feet.

[16] Singh, N. K. (2012), Development of digital map based fertility management system and fertilizer prescription in the soils of Sheikhpura and Nalanda districts by using soil survey information, Soil Survey & Land Use Planning Scheme, Bihar Agriculture University, Sabour.

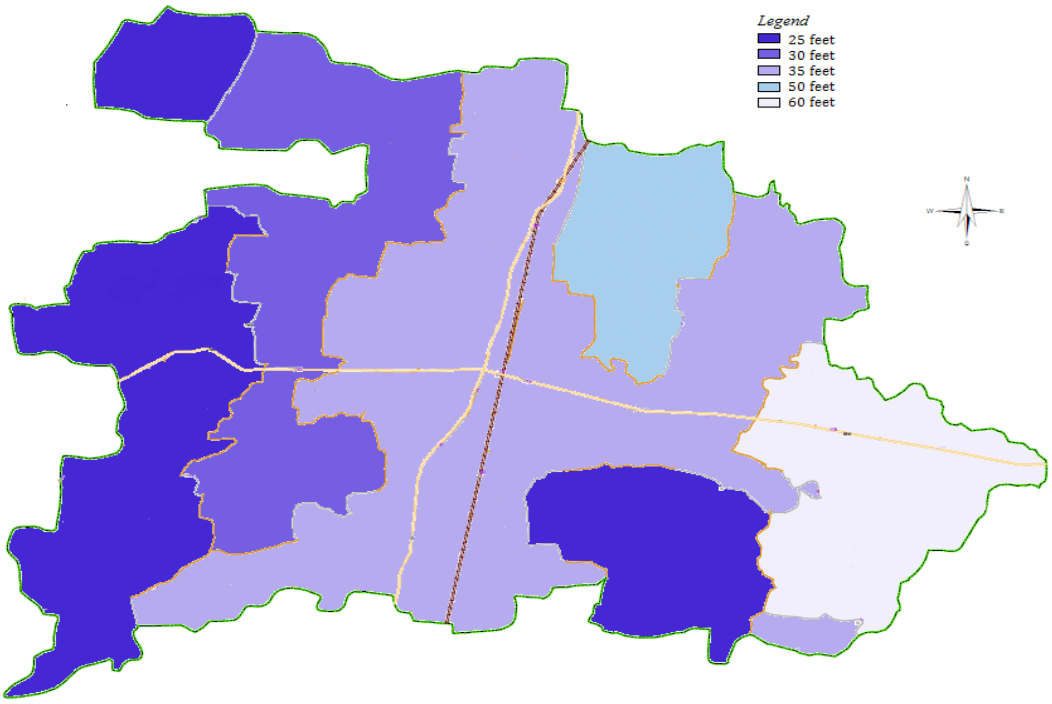


Figure 14 : Water level of Ekangar Sarai block in February (according to interviews)

4.1.1.3. *Micro reliefs in the landscape*

Landscapes are characterized by micro-reliefs; alternating low and high points can be observed every 250 metres. A height of 9 feet separates a higher part from a low area.

A study on soil types shows that sandy soils are found on high area and clay soils are met in lower areas (figure 15). Small particles (clay) are driven by leaching towards lower points. High soils are named *balwahi* soils (sandier soils) or *balsundi* soils, and soils on low points are named *kebal* soils. *Domat* soils, which are found on the slope, are intermediate soils, mix of sandy and clay soil. Accumulated water can be found in lower points at the end of the monsoon. In summer season these lower point are dry and there are slots (2-4cm) characteristic of clay swelling. Clay soils keep water, whereas sandy soils, where water percolates, become dry faster.

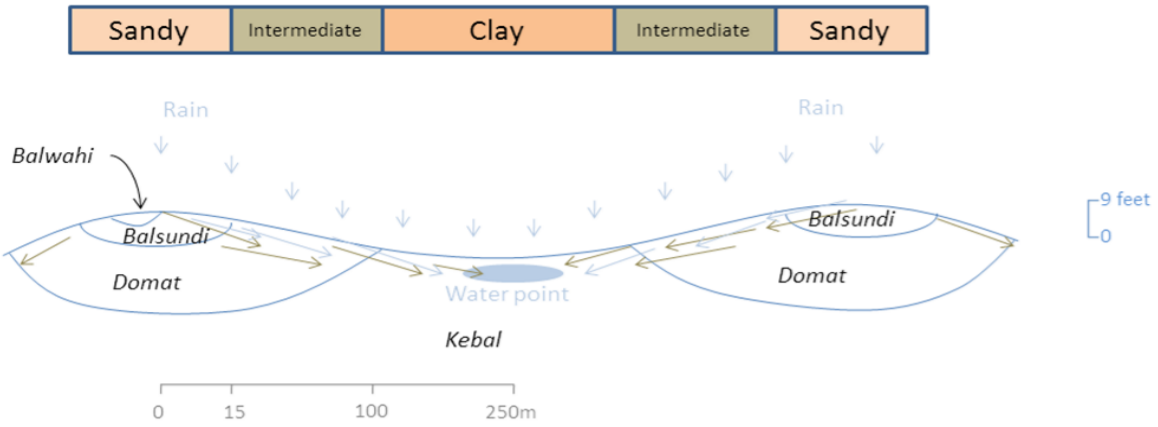


Figure 15 : Influence of micro-reliefs on soil differentiation

4.1.1.4. Men in the landscape

In each sub-division of the block, a representative (*mukhia*) is elected for a five-year term. In some villages, farmers refer to him in order to solve administrative issues. In the block, houses are clustered. Villages are located on high level points (figure 16). This allows avoiding flood. In villages, population ranges from 250 inhabitants to 6 000 inhabitants of the city of Ekangar Sarai. The village organization is centred on both castes and wealth. These two aspects could be linked. So, villages are divided in two parts. Scheduled castes, scheduled tribes and people who are not Hindu (including Muslims) do not mix with forward or backward castes. Moreover, in each part of the village, a financial power differentiation can be seen. Large residences are on one side and smaller on the other side.

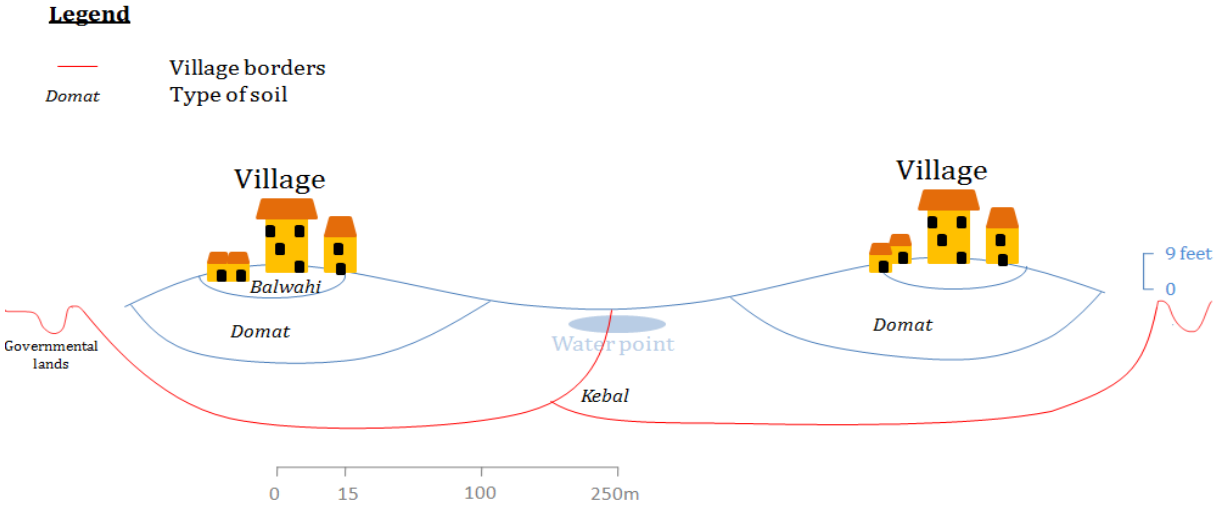


Figure 16 : Location of villages in the landscape

Each village has governmental lands, about 5 to 10% of total land. A part of them is located close to the village, and the rest is on the roadsides. These lands could be flooded canals during monsoon season. These canals could be used as border between two villages. Some parts of governmental lands have also been converted into plots by farmers.

In the whole territory, the tree layer is limited. It is located near the two intermittent rivers and along the canals (deciduous trees and tree of Taar), on some edges of fields (tree of Taar) or near houses (medicinal and fruit trees). The remaining landscape is dominated by fields. In average, plots are cultivated nine months a year. During summer season, drought prevents the planting of crops. However, some farmers grow 3 crops a year, depending on their financial ability and water availability.

Most of the time, farmer's lands are in their village. Plots are larger, in moving away from villages. The size varies from 2 katthas to 2 bighas (0,026 to 0,52ha). Plots are divided by small dykes (heightened dirt track). These dykes are built during the plot dividing. The oldest plots are demarcated by stones or bricks at the four corners.

As regards the wildlife, only species which can influence farming are discussed in this document. The most common mammal is the nilgai (*Boselaphus tragocamelus*), large antelope eating grass and crops (figure 17). There are also grasshoppers and partridges which can interfere with crops. Furthermore, there is a lack of earthworms.

Figure 17 : Nilgai (*Boselaphus tragocamelus*)

4.1.2. Use patterns of agro-ecological areas

In order to choose their crops, farmers take into account four factors: type of soil, water availability, plot visibility allowing monitoring, and facilities in order to sell their products. These factors lead to different crop and rotation choices.

4.1.2.1. Ekangar Sarai block, an intensive irrigated zone

In the study area, 90% of cultivated lands could be irrigated, based on field observations. However, access to water is unequal, across the block. Availability of irrigation systems and water are a key factor for farming.

During the study, several irrigation facilities have been observed (figure 20):

- Private boring: they are spread all over the landscape, and some of them are in former wells (figure 18). Water is drawn thanks to diesel or electric pumps. Then, it is flowed to plots with the help of semi-rigid or flexible plastic pipes. This equipment allows flood irrigation.

Figure 18 : Boring in a former well

- Governmental canals: monsoon rainfalls allow the filling of these canals. Farmers draw water thanks to diesel pump until March (figure 19).

Figure 19 : Governmental canal

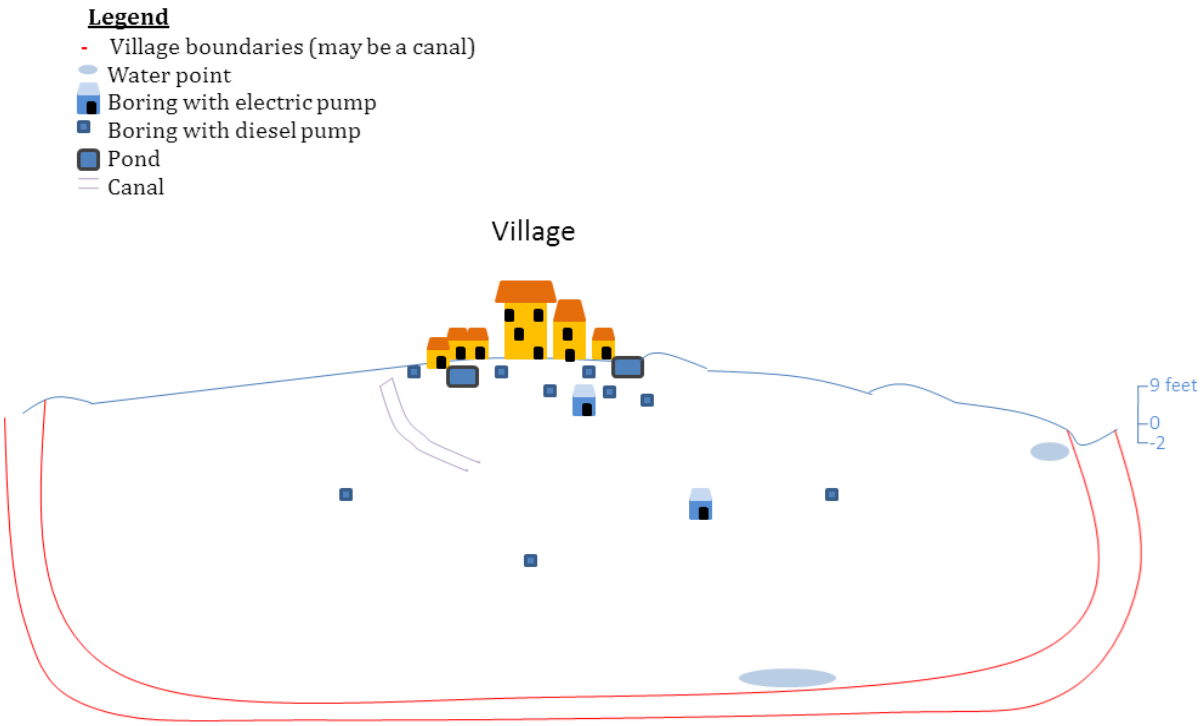


Figure 20 : Spatial location of borings

The choice between diesel and electric pump depends on various parameters. Electricity is cheaper but electric pump are heavier, and thus it is more difficult to transport them. Farmer, who has plots far away from his farm, will choose diesel pump. Moreover this choice depends on electricity availability.

Plots are levelled after each ploughing. However, small high points could always be observed. Farmers use these points when they irrigate their fields. They place pipes in this area, and plots could be flooded thanks to the tilt. Moreover, level differences between plots can be used for the irrigation. If a farmer has two adjoining plots, he would arrange the pipe in the highest plot and open exits through edges of fields. Water can flow out from the higher plot to the lower plot, without having to move the pipe. The lowest fields may contain a small man-made pond in order to collect excess water and avoid crop anoxia.

4.1.2.2. Factors affecting the crop location

Different factors can impact crop location. In the study area access to water and water surpluses look like two important factors. Indeed dry season and rainy season have impacts on crops. During rainy season crops have to resist to flood and water surpluses. Therefore farmers grow crops who can withstand to water excess like paddy in flood zone. Other crops are sow on high level lands where flood are less frequent (figure 21).

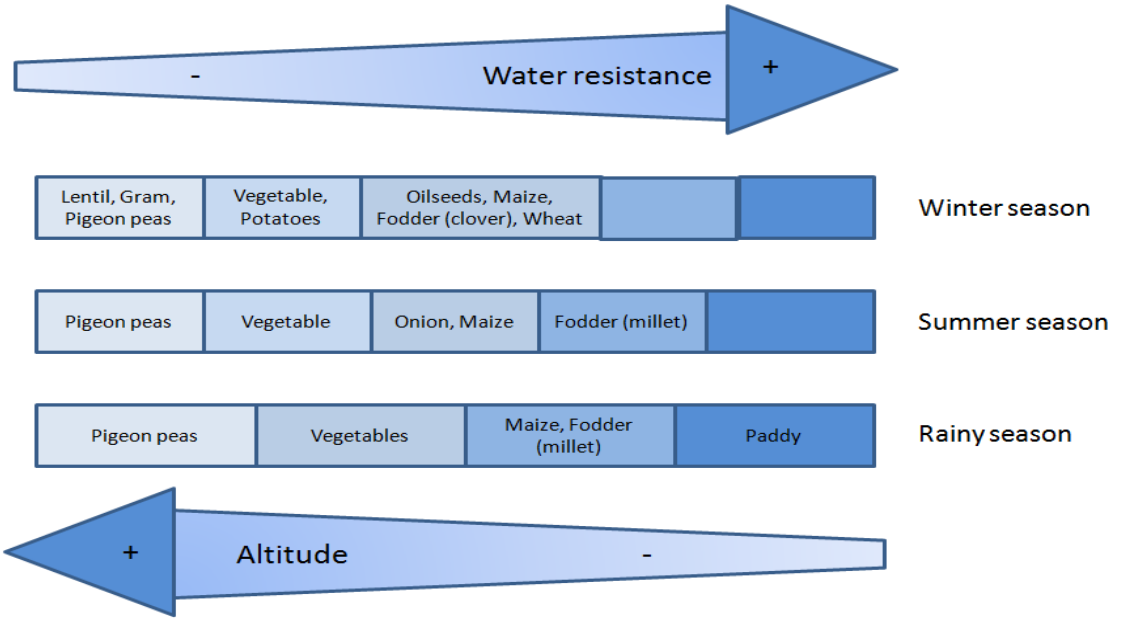


Figure 21 : Resistance to excess water

During dry season farmers have to adapt their practises to the lack of water. Indeed some crops have a better resistance to the drought (figure 22). This resistance impact irrigation frequency. Crops which resist less to drought should be irrigated more time. These crops will sow near a water point.

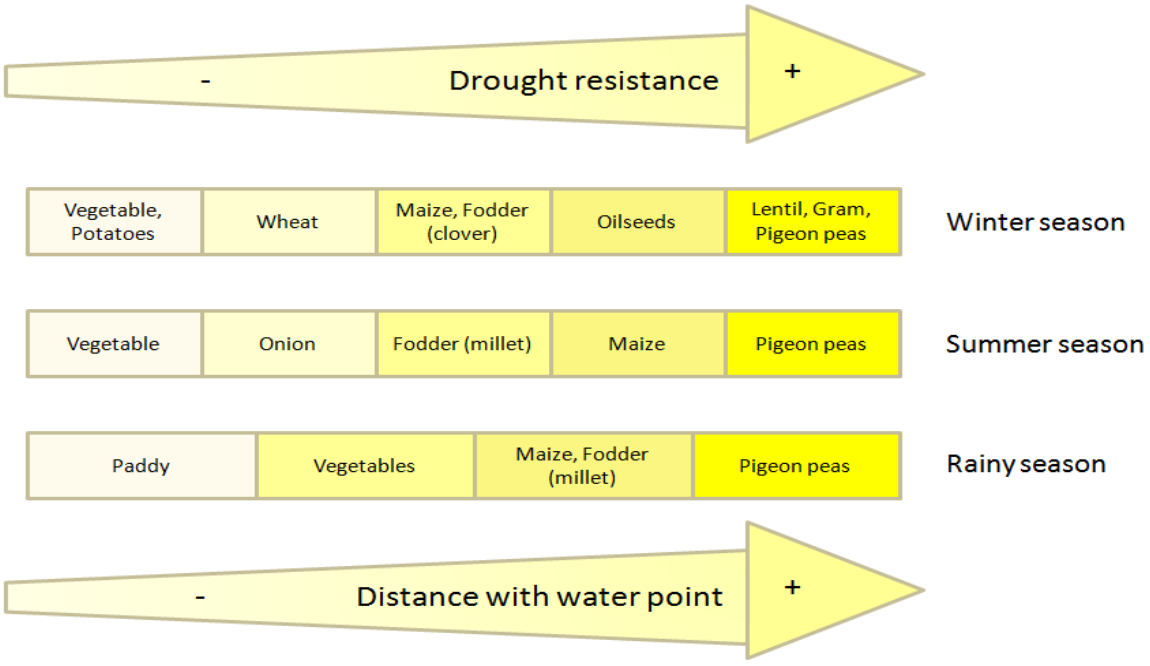


Figure 22 : Drought tolerance of crops

Clover, used as a fodder in order to fed animals, does not tolerate excess of water. Thus, it only grows during winter season. During rainy season, other fodders, such as millet, are cultivated.

However water excess and drought are also related to the type of soil. Clay soil located in low point keep more moisture. At the opposite sandy soil at the top of mounds dry more quickly. This point is different for vegetable. They are sow on sandy soil because they need a draining ground in order to limit the diseases.

Another factor which influences the choice of crops location is the distance between plots and residential areas. Crops are sought after by some of animals (nilgai) and humans. Thus, in order to protect their crops, farmers chose to grow them on the closest plots to their houses (figure 23).

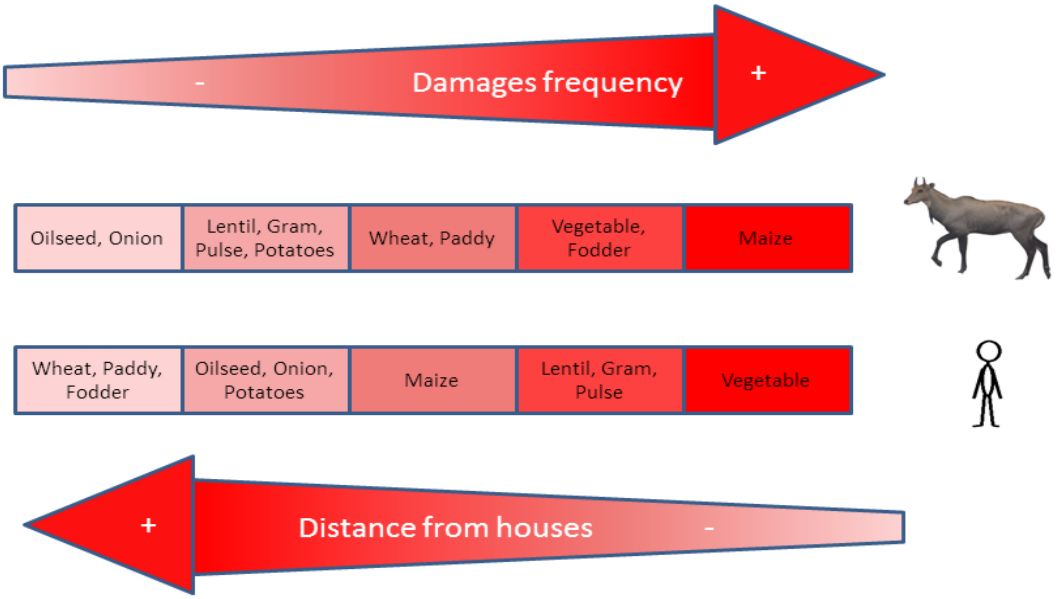


Figure 23 : Crop repartition according to the distance from houses

In some parts of the block, farmers had to stop their vegetable production because of the damage caused by the nilgai. This animal is protected, so farmers are powerless in the face of this threat.

Other factors may upset the crop location. We could mention farmer's lands, harvesting frequency and crop combinations.

- Some farmers do not have all the soil types and have to grow their crops in less favourable conditions.
- In order to improve space efficiency, some farmers use combination of crops on the same plot. The two main combinations are: wheat-rapeseed and lentil-mustard. Farmers do the lentil-mustard combination in order to protect lentils from the cold during the winter season. As regards the wheat-rapeseed combination, rapeseed could be planted at the edges of the plot, in order to protect wheat from nilgai attacks.
- The harvesting frequency is also an important factor. Fodder and vegetables are preferentially planted near the houses because farmers regularly harvest these crops.

Mustard could be used to protect crops after harvesting against rodents.

In Ekangar Sarai block, farmers make the following choices (figure 24):

- On the highest points near the house (zone A): sandy soils have a water holding capacity of ten days. In winter season, crops which are preferentially planted on these areas are: vegetables, maize, mustard, lentils and grams. During this season, there are two logics. On the one hand, vegetables grow in the zone A because the fast percolation of water limits disease pressure and the irrigation lead to high yields. Furthermore plots are near water points. On the other hand, lentil, gram, mustard and maize are planted here because they have low water needs. Moreover these crops need to be protected to nilgai and thefts. During the rainy season, vegetables and maize are sown on these lands because they can be destructed by water excess. In summer season vegetable are sow because sandy soil is suitable for their production. Moreover, in this zone A, there are raised lands with sandy draining soils (zone A'). Pigeon peas are usually grown in these areas.
- On low points (zone C): the high clay content allows maintaining high moisture content during 50 days in winter season that is good for the growth of plants. Moreover, these plots are located faraway from the water points, so irrigation is difficult. In winter season, crops which need less water are growing on these zones: lentils, gram and grass peas. These crops use the water moisture remaining to grow. In summer, no crop grows on zone C. In rainy season, paddy rice is sown in this zone because this crop can tolerate large quantities of water and these soils are flooded.
- The slope (zone B): it is an intermediate soil which has a water holding capacity of 15 to 20 days, during winter season. Crops which are grown are: wheat, rapeseed, which is often mixed with wheat, and potatoes. Moreover most of water points are in this zone. This allows irrigating the crops in function of needs. During summer season, onions are transplanted on these plots. In rainy season, all varieties of paddy rice could be grown.

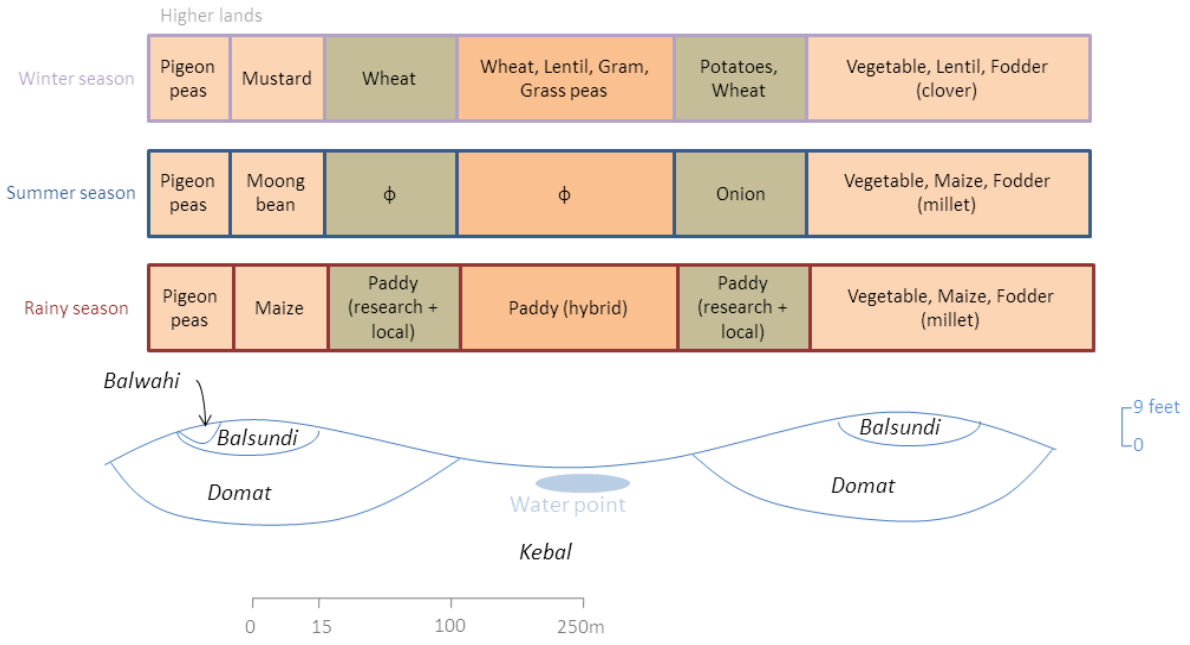


Figure 24 : Crops organization according to soil types

4.1.3. Agro-ecological zoning

When account is taken of infrastructures and the whole of the foregoing factors, we can differentiate four zones (figure 25).

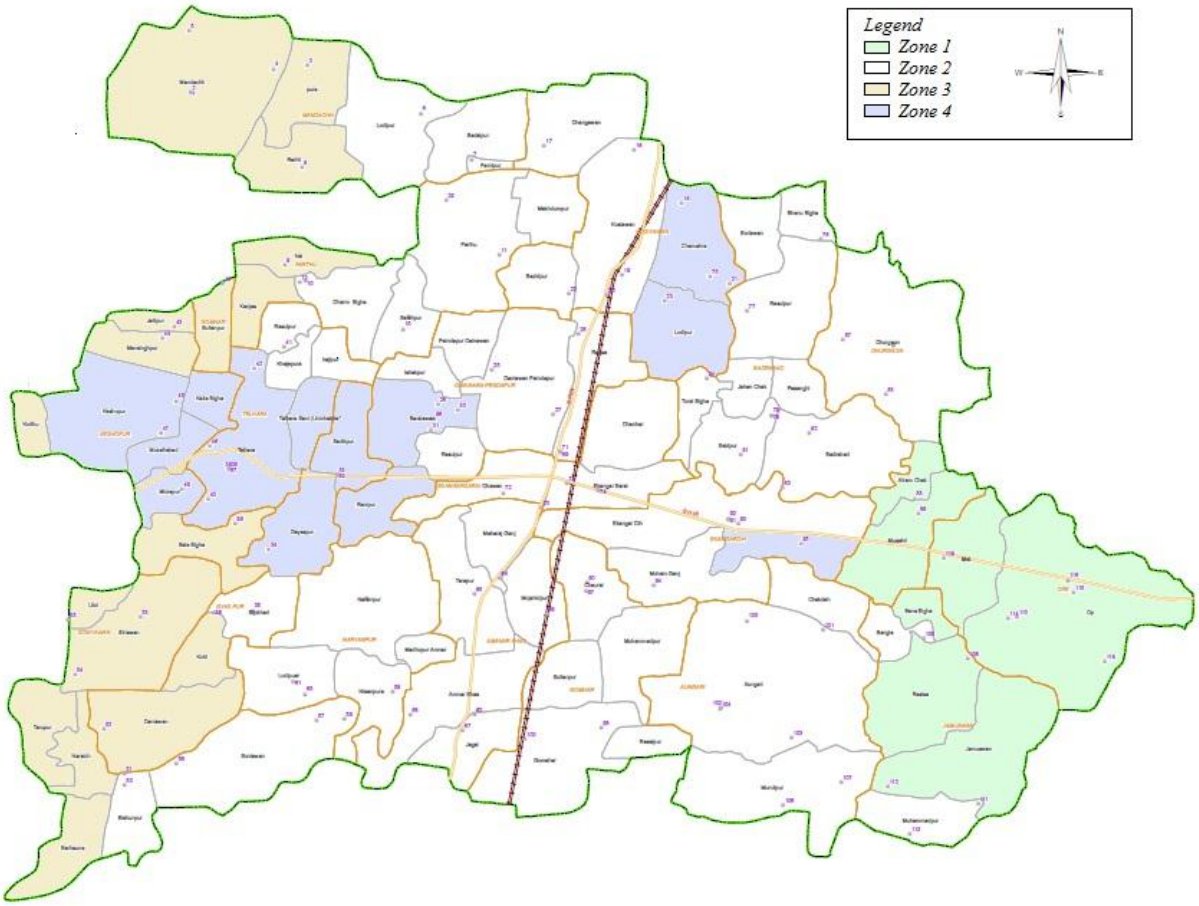


Figure 25 : Delimitation of working areas

4.1.3.1. Zone 1

The zone 1 is located in the east of the block. In this area, the level of water table is lower than 60 feet. Because of this low water reserve and the small amount of irrigation facilities, almost 40% of lands are uncultivated or cultivated only during the rainy season, with paddy crop. In winter season, the main crops are pulses, because they have low water requirement. Near irrigation systems, wheat could be found. Very limited lands are dedicated to vegetable crops, mainly potatoes could be found. During summer season, almost all lands lie fallow.

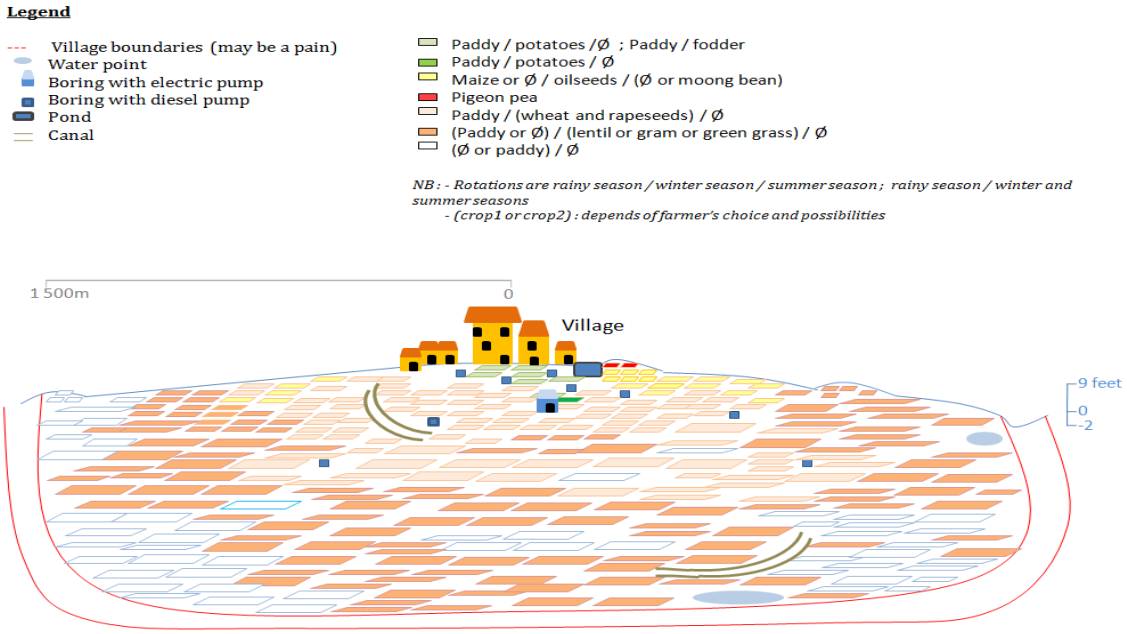


Figure 26 : Zone 1

4.1.3.2. Zone 2

This zone is the largest area. Water table level is higher than in the first zone, it is around 30 to 50 feet. In the area, there are more irrigation equipments, and during winter and rainy season, almost all lands are cultivated. Vegetable production is found throughout the year, mainly for self-consumption but some vegetables could be sold.

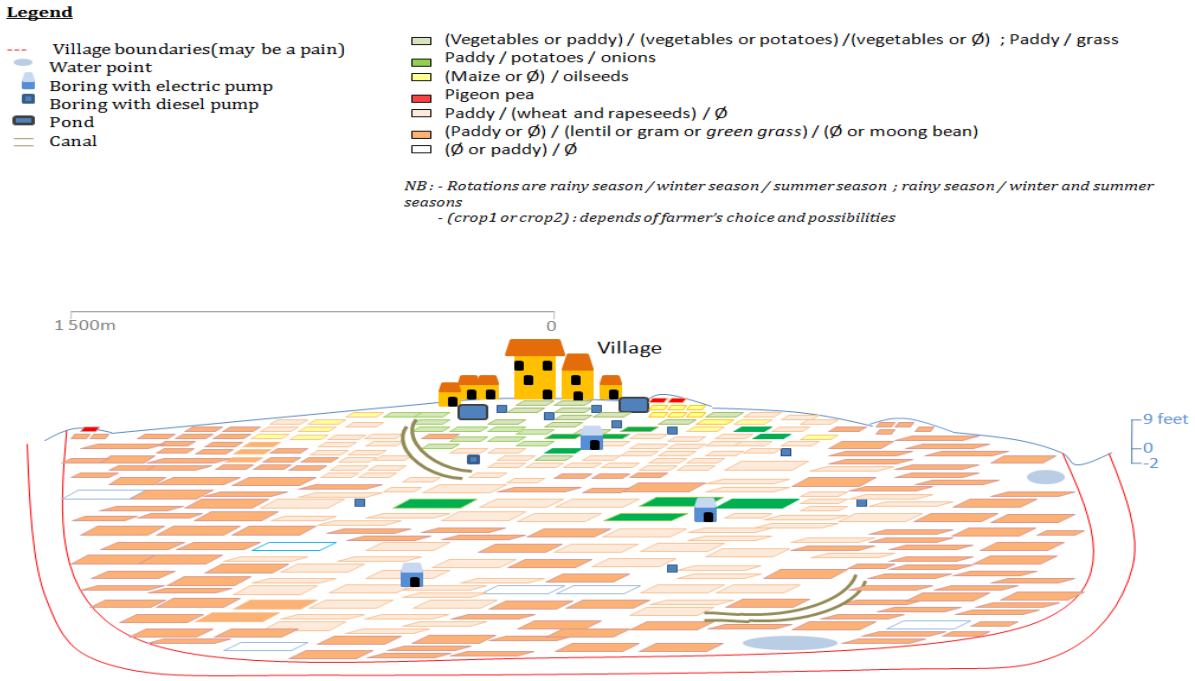


Figure 27 : Zone 2

4.1.3.3. Zone 3

The third zone is in the western part of the block, along the Phalgu River. Its close proximity to this river leads to a high level of groundwater (around 25 feet at the beginning of winter). The high water availability allows cultivating wheat in large areas during winter season (75% of lands) and paddy in rainy season. The percentage of sand is high, clay soils are limited. Vegetable crops are mostly self-consumed during the whole of the year.

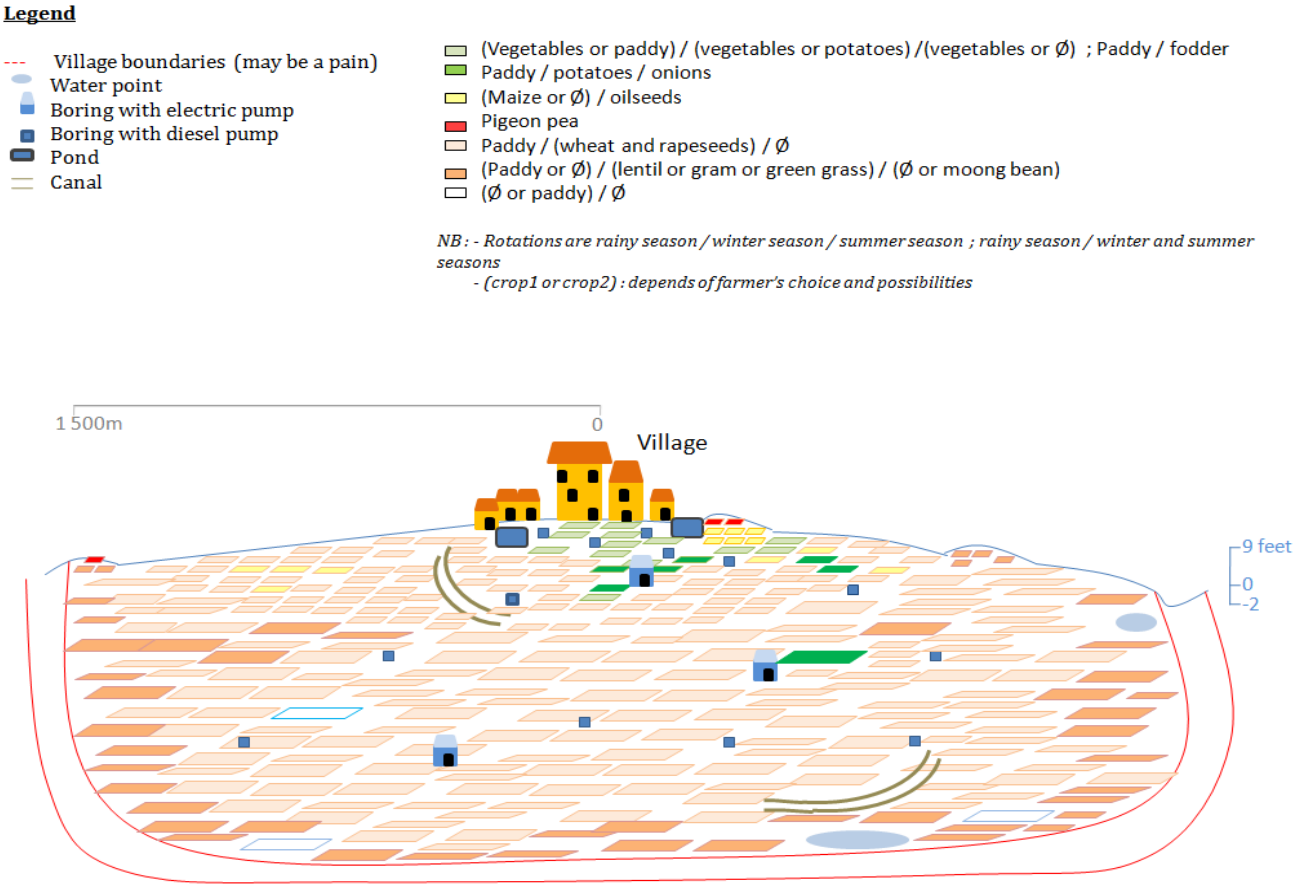


Figure 28 : Zone 3

4.1.3.4. Zone4

The zone 4 is located in the central-eastern part of the block. This area, near the river, consists largely of sandy soils (*balwahi*) and intermediate soils (*domat*). Groundwater level is between 25 to 30 feet, at the beginning of winter. The national road crosses this zone, which improves access to Ekangar Sarai and Janabad markets. Therefore, in this area, vegetables production (including potatoes and onions) is very important. According to field observations, 30% of the cultivated lands are planted with vegetables, all year round.

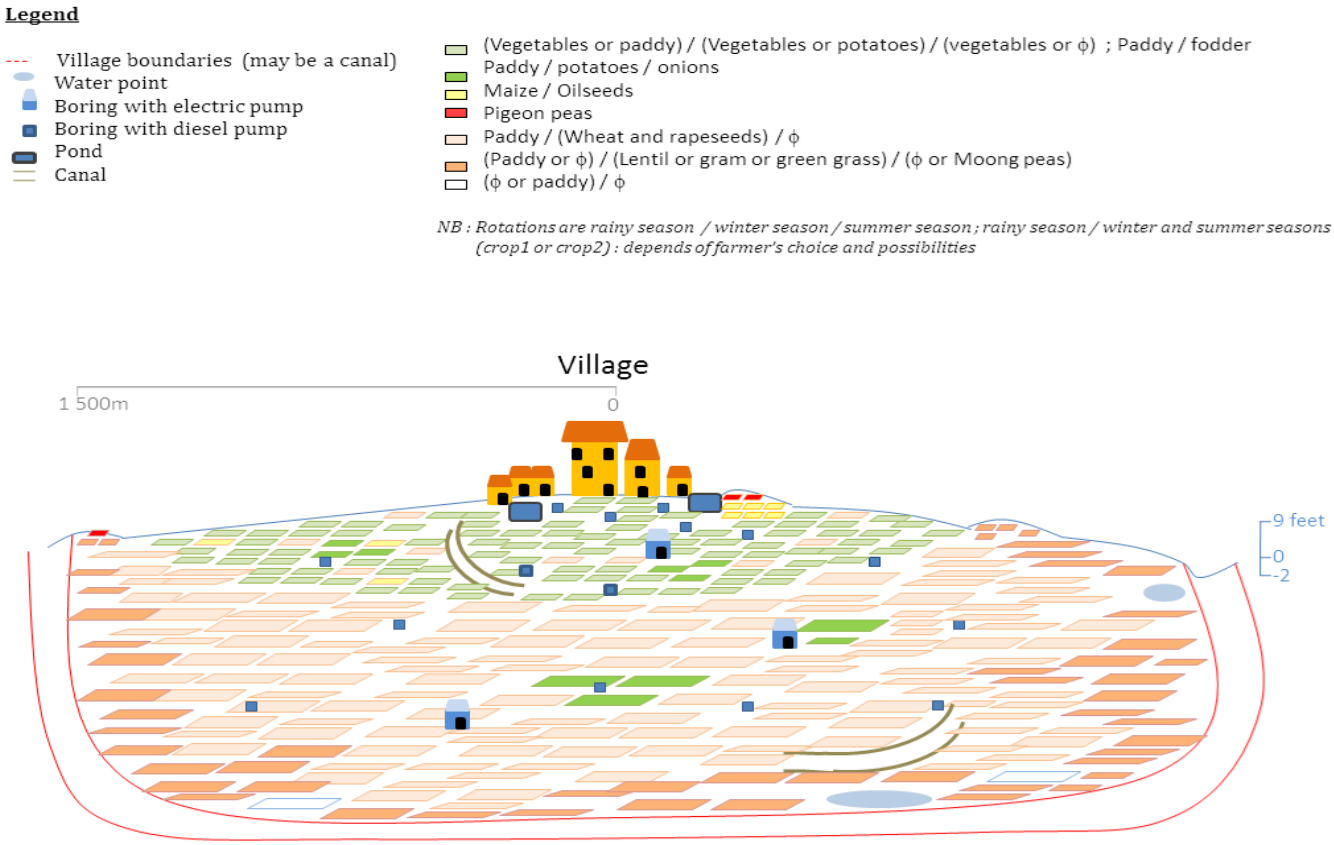


Figure 29 : Zone 4

4.1.3.5. Livestock

As regards the livestock, the whole territory is similar, except in the zone 4 where the number of buffalos and goats is more important. In the block, 5 different types of animals are reared.

- Cattle and buffalos for milk and dung production. Dejections are used as fuel for cooking Farmers have 1 to 2 animals, on average. However, some farms tend to increase their milk production and can have until 5 to 8 bovines. In some villages, which are difficult to access, farmers keep oxen in order to plough fields.
- Goats for meat production. The herd consists of about 3 adult goats. Most of the time, goats graze in fields or on the roadside.
- Sheep for meat production. Sheep are held by some rare shepherds.
- Hens for meat production. These animals are only raised in poor part of villages. Furthermore, some cage-rearing of poultry are present in the block.
- Fishes for meat production. These fishes are kept in natural or artificial ponds.

5. Agrarian history

In the following part we describe what we have understood of the history of the last 80 years. Just few documents speak about the history of this block. Moreover most of people living at that time passed away. As the consequence, some parts could miss. A historical timeline, in annex, recaps the significant dates.

5.1.The block before independence

5.1.1. Organization of the society

At that time, all lands belonged legally to the government. The zamindars had to look after these lands and collect taxes. They were intermediaries between farmers and government. They lived in developed cities of the Ekangar Sarai block, such as Aungari, Dhurgaon, Chamera, Kadilpur. They belonged to different castes and religion (Kurmi, Bhumiar, Brahman, Muslims, etc). Indeed, they have been chosen because they were powerful and respected in the small area where they lived, and not only because they belonged to upper castes. In order to collect taxes and organise the territory, they hired intermediaries. These people were friendly with the zamindars, and belonged most of the time to forward casts (Rajput, Brahi…). They could keep a part of the taxes for themselves.

Even if lands were the government's property, there were different types of informal owners:

- Zamindars who had lands before the arrival of British and kept one part of lands that they had to control.
- Land owners who had lands before the arrival of British. They had to be able to pay taxes.

If people could not pay taxes, the zamindars kept their lands. These lands were sold to other people. If one people wanted to buy some lands, it was easier for him to have good relation with the zamindars. However, taxes were different in the study area. In remote areas, taxes were less important than in areas near zamindars' residences. Where zamindars lived, small farmers could not keep their lands. They were strangled by taxes. Thus, at that time, rich farmers who were able to purchase lands became bigger; and other farmers lost their lands and became tenants.

Although they had no lands at the beginning, intermediaries were gradually able to buy some lands as well. It was lands who were grabbed by zamindars.

The land owners hired permanent workers, who belonged to scheduled castes, in order to cultivate their agricultural lands. They also gave their lands to tenants. A large part of tenants were Yadav. Indeed, historically, Yadav lived on livestock rearing, and they had no lands. Thus, they had to lease them.

If we recap all the information, we can say that the society was organised in pyramid (figure 30). At the top of this pyramid were the zamindars. They had some lands, and they control and organise the area. At the second level were intermediaries who collected taxes and grabbed some lands. At the third level were informal land owners. At the fourth level were tenants. They cultivated lands of the previous levels. And they hired workers who composed the last level. These workers could also work for the three first levels.

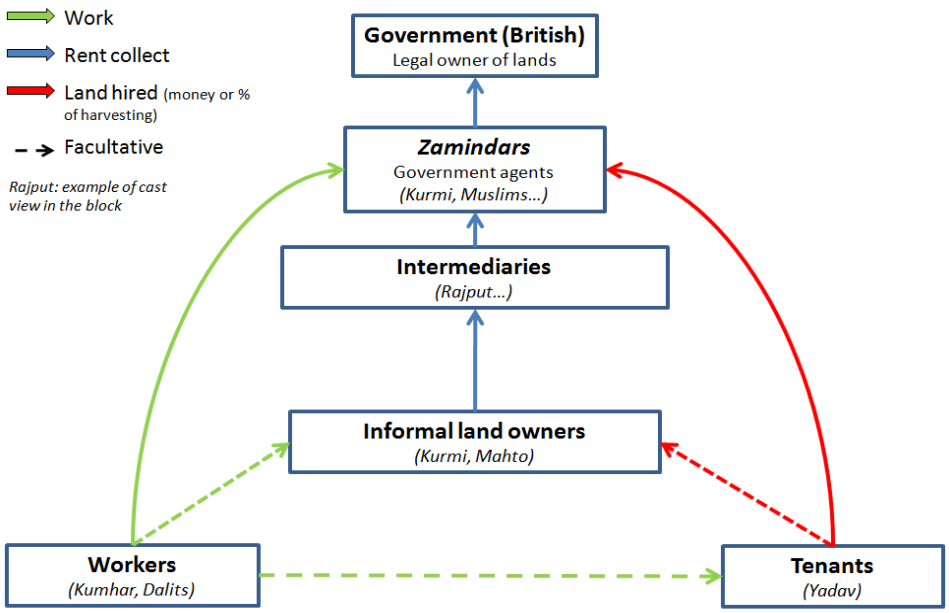


Figure 30 : Society organization before independence

5.1.2. Organization of the territory

During the British rule, only 50% of the territory was cultivated, due to the lack of irrigation facilities and the manpower requirements. Crops grew in rainy and winter seasons. Different systems irrigated these crops.

- During winter season, farmers used only wells. They were built by British people. In some parts of the block we can find one well every 100 metres. Farmers used oxen or workers to draw water from wells. Oxen caused the rotation of a wheel which lifts buckets of water. Then, water was poured in small canals which carried out it to plots. This irrigation system is named Persian wheel, or *reghat* in the study area (figure 31).

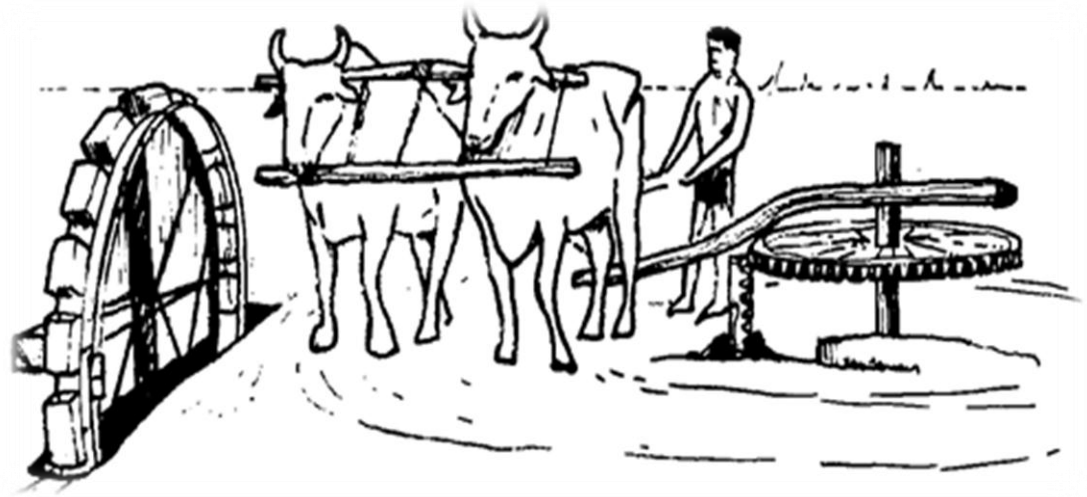


Figure 31 : Representation of Reghat system

- In rainy season besides wells, farmers used canals named *ahars*. These canals, always used today, were located in border of villages. They collected run-off water. They were full of water during four months. In order to lift water, farmers used a lift mast which involved the raise of bucket. After drawing water, small canals or workers carry water to fields. Cultivated plots were located near houses or canals in order to facilitate irrigation.

In rainy season, main crops were paddy, which required irrigation (figure 32). Finger millet and maize also grew in this season, on high level lands. During winter season, farmers cultivated mainly grass pea, but potatoes oilseeds, grams and lentils as well. Some crops such as sugar cane and pigeon pea grew all year long.

At that time each farmers had minimum a pair of oxen. Oxen ploughed plots and draw water from wells. There were less females producing milk, herd of milk-producing animals did not exceed two to three adults. These animals produced 3-4 litres of milk during the lactation peak. Farmers self-consumed their milk. They had difficulty to sell their dairy products. As we have seen, lots of lands are fallows. Thus, animals could graze on these fields. Their ration was supplemented by grass pea and straw (finger millet and paddy straw). Moreover, some farmers cultivated fodders. Farmers used dung as fuel for coking and as manure. They applied seventy kilograms of manure per kattha (0.012ha). Thus, crop-livestock integration was important. Animals provided manure and draught power in order to cultivate lands. In exchange, crop residues were used in order to feed them.

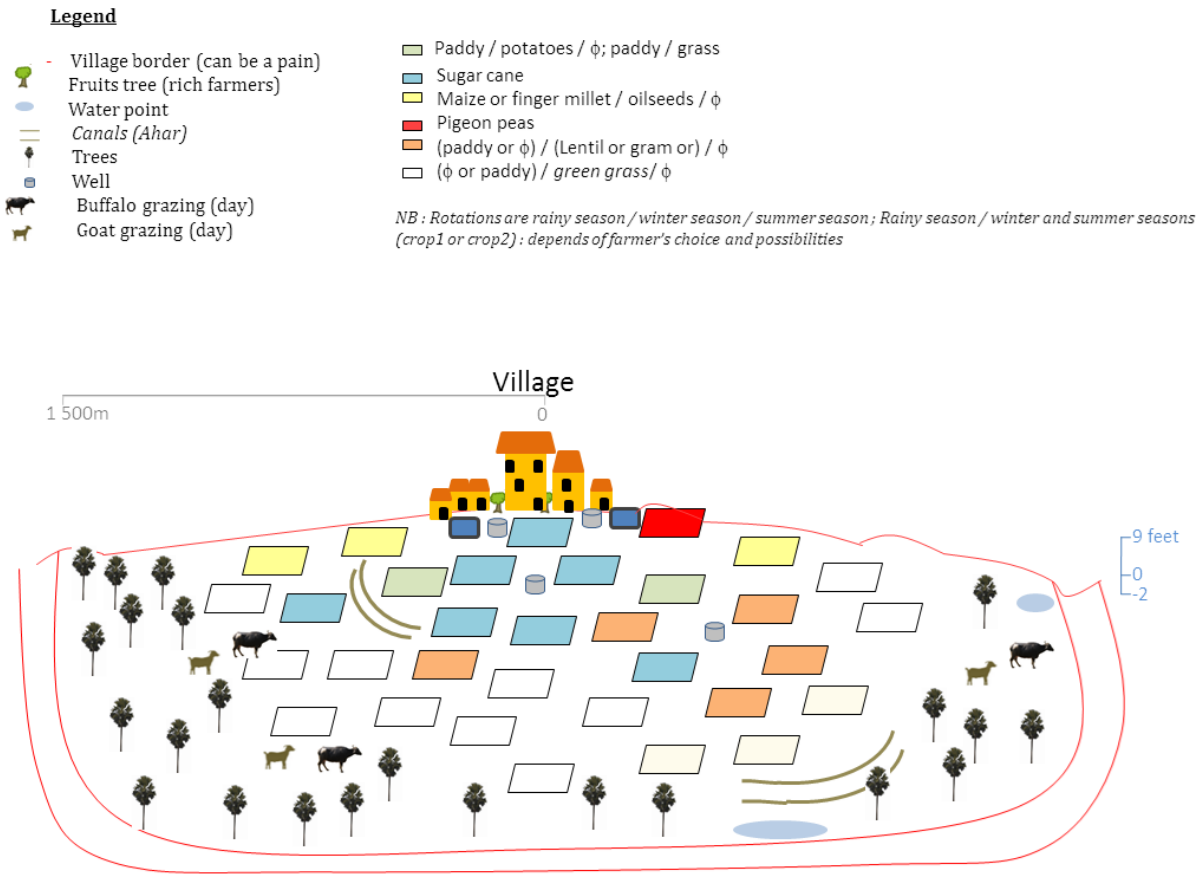


Figure 32 : landscape between 1940 and 1960

5.2. The block after Independence: the end of British India and land distribution

In 1947, India became independent and the zamindari system has been legally abolished. However, it continued during three to fifteen years, according to the areas. At that time, some rich farmers belonging to the forward or backward castes had lots of land, about 160 bighas (40ha). On the other hand, lots of people who cultivated plots (tenants and workers) had no land. In response, the government tried to redistribute lands. The "*Bihar Land Reform Act*" was edited in 1962. This act limited the size of lands (10ha) and distributed surplus of lands to landless. Delegates came and counted land size. Nevertheless, in Ekangar Sarai block none of farmers lost lands. Big farmers divided their lands between family members. However, it seems government has brought together lands which were scattered.

The failure of this act led to the creation in 1970 of "*Bihar tenancy act*". This act:

- Restricted land size to 10 hectares.
- Limit land division between family members. In order to achieve this goal, the act fixed the family composition.
- Protected small owners' interests.

Once more, this act did not reach its target. Some big owners kept their lands.

Nevertheless, when the zamindari system was abolished, some zamindars left the block and went to cities. They wanted to improve their living conditions. Their lands were sold. However at that time there were lots of corruptions. The zamindars sold their lands only to friend people. Tenant captured only marginal lands. We note also that in areas near zamindars' residences just few lands were distributed to tenants. Workers did not receive lands.

All these events led to a change of land distribution (figure 33):

- Zamindars who went to cities sold their lands.
- Zamindars who stayed in the bloc kept most of their lands
- Rich land owners kept their lands and bought some zamindars' lands.
- Rich people, who lived in cities, bought some zamindars' lands.
- Other land owners kept their lands.
- Tenant grabbed some lands or government gave them some lands.

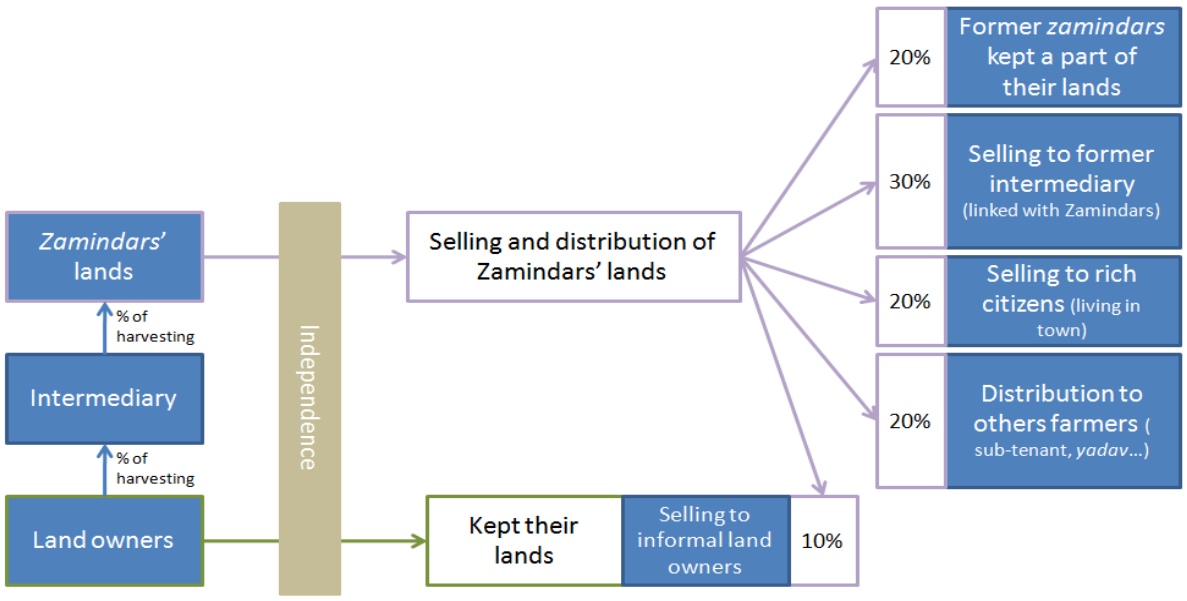


Figure 33 : Land distribution at the end of Zamindari system (estimated in percentage)

The abolition of zamindari system led to repression. Some Muslims' villages were destroyed by other people. These people capture also Muslims' lands. However some Muslims stayed in these villages.

5.3.Le block between 1970-1980: green revolution and migration towards Anglophone countries

5.3.1. Migration to English-speaking countries

Between 1970 and 1980, children of rich farmers studied in best school. They learnt to speak English. However, India was not a developed country, and there was no opportunity for these high qualified students. Moreover they looked for better living conditions. They decided to leave India in order to find a work. They went to English-speaking countries like England, Canada, USA, and Australia. However only rich family went to foreign countries, others cannot pay fly tickets. In 1980, India government offered good places to the high qualified people. Therefore, the migration decreased.

In the study area, around seven hundred people left India. Most of the time, they lived in the same villages where zamindars were. They rented their land to their family or to tenants. Their families collected rent and it.

5.3.2. 1966: A dry year which promoted the green revolution

In 1966, a big drought destroyed most of the harvests. This drought occurred during rainy season and lots of farmers lost their paddy crops. According to farmers, this drought led to a 20 feet decrease of the ground water level. This decrease of ground water level combined with the lack of precipitation led to low soil moisture content. This prevented to grow winter crop. Besides, there was not enough grass to feed cattle. Farmers had to use palm leaves. They lost a part of their herd.

After this event farmers were shocked. In order not to relive another drought, rich farmers chose to create borings. Some of them reused old well and the richest built new. The boring position was determined by plot location. Farmer built equipment near the area where the maximum of their plots were present. Even if electricity arrived in 1957 in some villages, famers bought diesel pumps to draw water. They needed fewer workers to irrigate their fields.

The development of borings allows securing crops and farmers had more opportunities. Cultivated area increased instead of the tree layer. As a consequent, there were fewer lands to graze and farmers started to rear bovine in tie-stalls. Faced with the decrease of grazing areas and the decrease of grass pea growing, replaced by wheat, farmers cultivated more fodders, such as clover and millet, in order to feed their animals.

As we have seen previously, farmers began growing wheat, which gradually replaced grass pea. Indeed, the better water availability allows the wheat growing during winter season. During rainy season, farmers also grow more paddy. They started to cultivate new varieties which had shorter growth cycle and gave higher yields. Production of finger millet, pigeon pea and sugarcane decrease gradually (figure 34).

Indian government helped farmers to purchase equipment and inputs. In the Ekangar Sarai block some farmers bought tractors which replaced oxen. Chemical fertilisers, which gradually replaced manure, were applied on fields to improve yields, 1kg per kattha and per year in 1974.

The Green Revolution, characterized by the development of irrigation, new varieties and chemical fertilisers, widened the gap between farmers. Rich and big farmers who had tractor and boring and who were using fertilizers and new varieties, produced more and more. These farmers stimulate the development of the area. At the powerful farmers' request, government created roads and electric net to serve remote areas. There were some differences between areas of the block. Areas, where zamindars lived, were richer than the others. More powerful and influent farmers were present. As a result, more borings and equipment were built in these areas. On the contrary, poorer farmers who are small owners, tenants or workers could not access to these facilities and inputs.

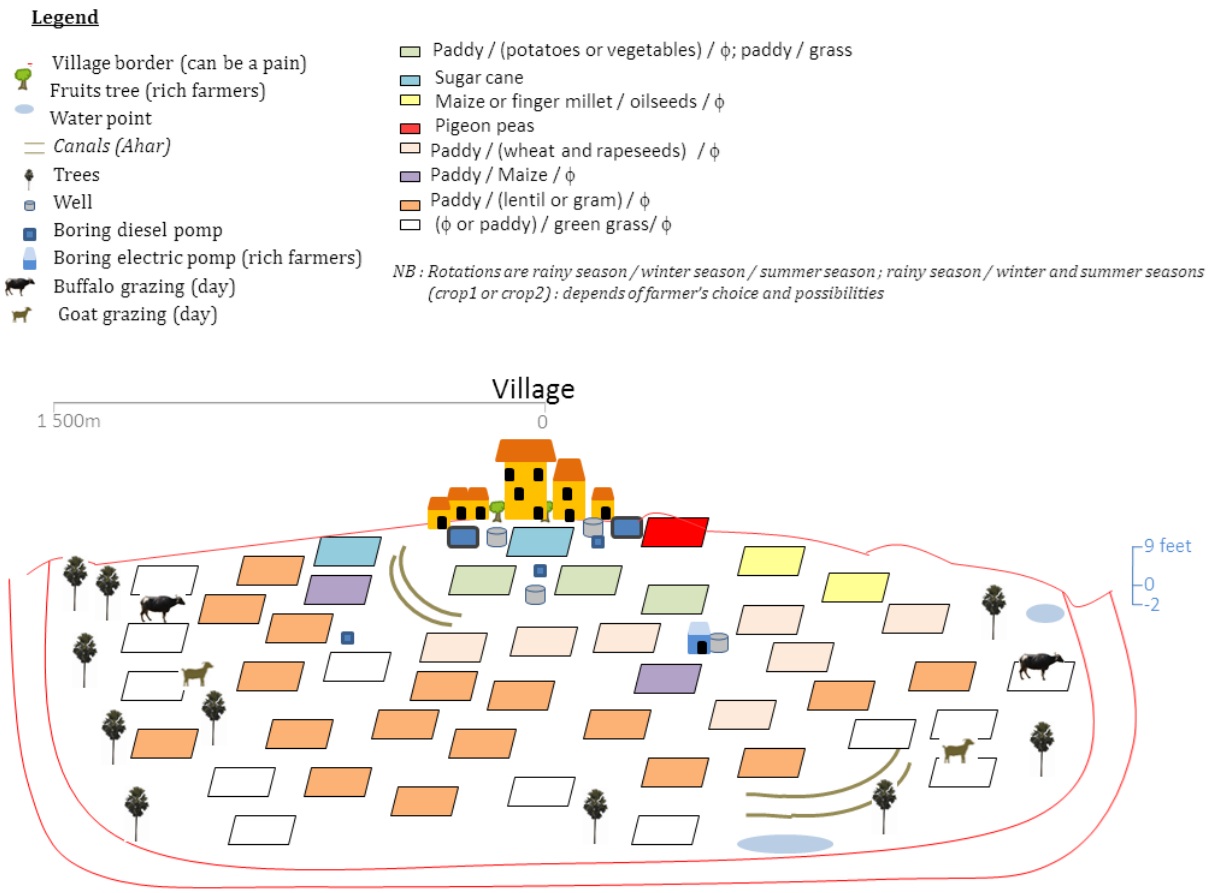


Figure 34: landscape between 1962 and 1980

In 1972, Indian government created the Primary Agricultural Cooperative Society (PACS). This PACS allowed having fertilisers, seeds and loans to interest rates. Farmers had to pay 10 000Rs to enter in this cooperative. They elected representatives every two years. A representative could not be re-elected four years after his mandate. Until 1992, only rich farmers belonged to this PACS. Government thought that only big farmers could develop the area because they produce more quantity. In 1992, government noted that there were lots of small farmers who were excluded from this PACS that was why they changed their point of view, and looked at conditions of admission again.

Today, there is one PACS in each panchayat. Representatives are elected for four years and they can be re-elected. PACS sells fertilisers and seeds to farmers. Prices are more interesting than in market. Besides, farmers sell paddy to the PACS. This paddy is redistributed to poor people who have below poverty line cards (BPL cards). This paddy supplies the Public Distribution System (PDS) (figure 35). However just few farmers can touch this advantage. First, farmers have to be owner of lands. Moreover, mall farmers do not sell paddy to the PACS because there is a long delay before payment and they need money. Furthermore, it is more difficult to have loans.

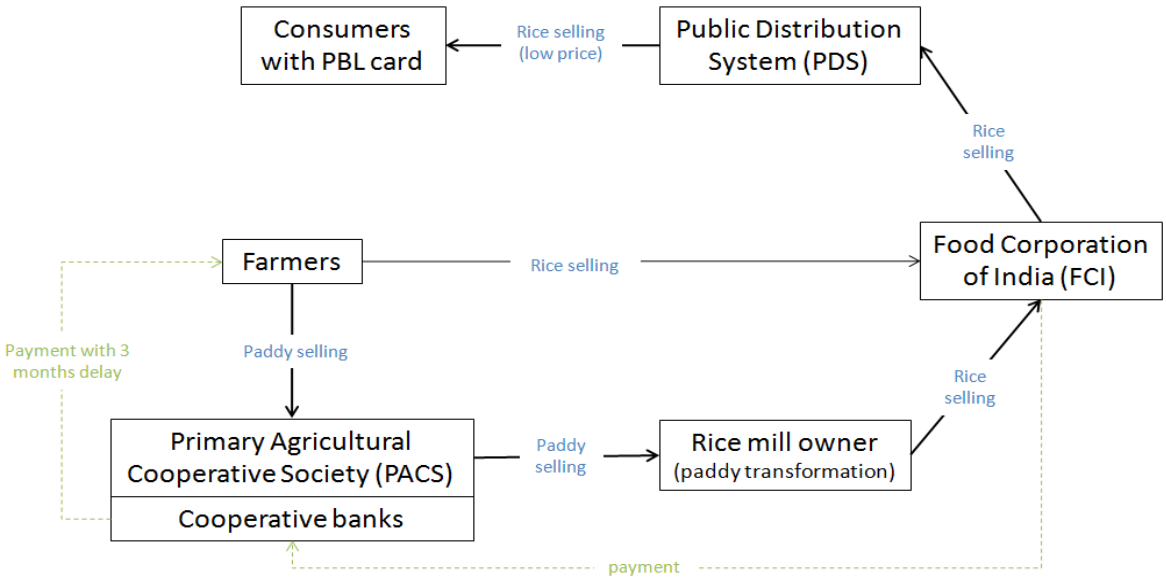


Figure 35: Enhancing the value of paddy in PACS, via the PDS

5.4. The Block between 1980 and 2000: a second migration, a new valuation of lands and development of gardening farms

5.4.1. The second migration towards big cities of India

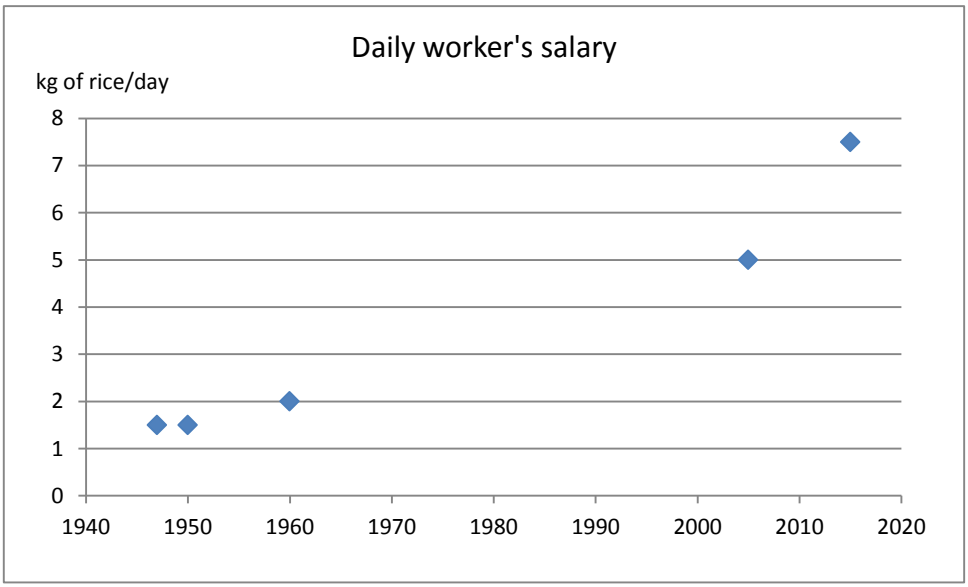
5.4.1.1. Migration of landless

Before 1980, land owners hired permanent labours to work on their plots. Most of these workers lived on farms. They earned 1 to 1.5 kg of rice or wheat per day. Moreover landowners gave to them 10 katthas of land (0.125ha). Landowners also hired some daily workers when they needed.

However with the green revolution, landowners started to use tractors and mechanisation. Irrigation with the development of boring requires less workforce than when they used only well and canals. As a consequence, farm work requires much less labour force. Owners of lands hired fewer labourers, and especially permanent labourers which were replaced by daily workers. Indeed, government edited new rules to preserve labourers' working conditions and these workers asked for better conditions, as well. As a result, landowners chose to hire daily workers. If they had money issue they could regulate the number of workers and promote competition.

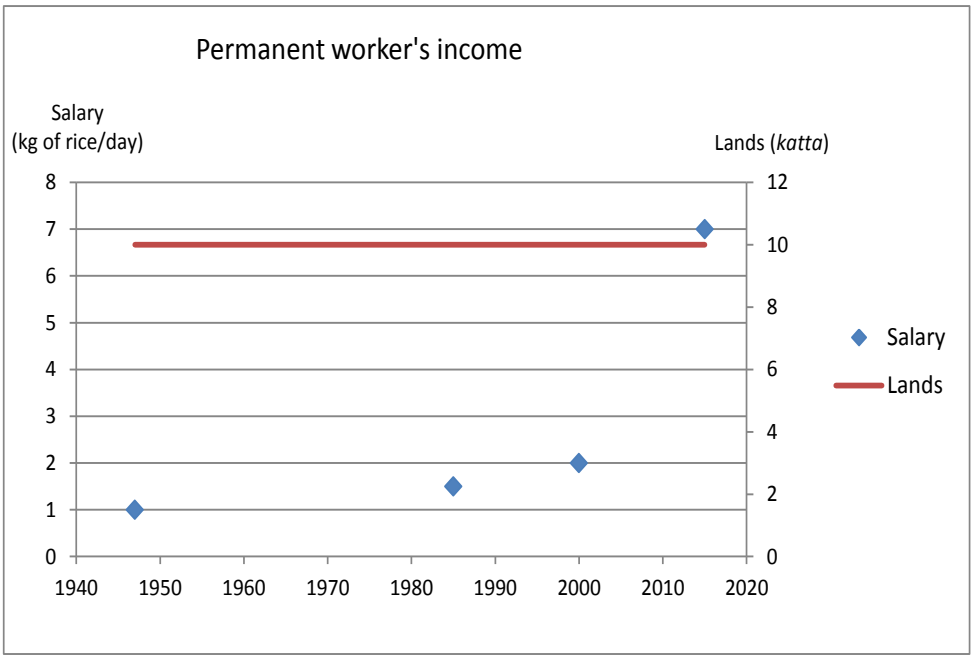
On the other side, India followed its development. Factories were built and they needed workers to function. Cities became more attractive for people who were living in countryside. Moreover, labourers were bored by farm working conditions. They wanted to earn cash money and to have fixe timetable. Last but not least, they were bored to be bullied by landowners and wished to become free. Therefore, landless started to go away. Most of the time, they went to other states or cities temporarily and came back during the peak workload. During the rest of the year, a member of the family does farm work. Some of them migrated definitively. However some farmers, migrating to cities, did not find a job and they lived in shanty houses. But they did not want to come back to villages. They hoped to find something.

According to owners of lands who have to hire some labourers, this great migration brings about a lack of labourers in the block. Indeed, they had fewer choices to hire labourers and they had to spend more money because of the competition (graph 4). In order to prevent this, they decided to purchase more equipment. So workers find less work and this still go on.



Graph 4 : Daily workers salary (without taking account of inflation)

Nowadays, there are still some permanent labourers in the study area. There, income increased (graph 5).



Graph 5 : permanent workers income (without taking account of inflation)

5.4.1.2. Landowner migration

Rich landowners could pay a good education to their child. Their teenagers became high qualified. The development of tertiary sector, in big cities, offered the opportunity to find a job. That why children chose to go away and live in biggest city. Moreover at that time, Bihar was a poor and undeveloped state. This state did not offer opportunity. As a consequence, they went to other states and they rented their land to tenants.

Nowadays, these two migrations follow. In some villages, more than 50 per cent of population have left. We have seen abandoned villages. The landless lived in these villages. Sometimes, they could not find enough farm labour to live because owners of lands did not want to hire lots of labourers. Moreover, landowners did not want to rent them some lands. They had no choice, and gradually they chose to go away.

5.4.2. Method to enhance the value of lands

Living in cities, landowners were not in the block to cultivate their plots. Moreover, the increase of labour costs lead to a decrease of landowners' profit. They chose to hire fewer workers. Thus, the rules of working conditions have changed. All these parameters changed the form of land use. Some landowners started to give their land to other farmers. There were two types of landowners. First, there were absent landowners who were living in cities. These people rented their lands to tenants. The landowners who stayed on villages to live preferred to give their lands to sharecroppers. They could look after harvest and control what was happen on their lands. Nowadays, in Ekangar Sarai block, there are four contracts (two lease contracts and two sharecropping contracts):

- Chaurha contract: tenants give fixed quantity of paddy or wheat, about 320kg/bigha (0.25ha). This contract can change if there are low yields. Tenants choose crops and have to pay all inputs.
- Patta contract: tenants give a fixed amount, between 6 000 to 10 000Rs per bigha (0.25 ha) to landowners. The amount varies according to land quality.
- Battya contract: the increase in inputs which are applied on fields could lead to the apparition of this contract. Indeed, in the contract, input costs are shared between landowners and sharecroppers, and sharecroppers have to give fifty per cent of the harvest. Sharecroppers choose crops but choice is affected by owner authority.
- Tehayia contract: Landowner pays all input costs. Sharecroppers work in field and earn 33% of harvest. Landowner chooses crops.

In the Ekangar Sarai block, most of landowners choose chaurha to valorise their lands. Today in some villages 80% of lands are given to sharecroppers or tenants.

Different factors could influence the choice of landless or small landowner to rent some lands. If landowners consider them to be too old to hire them as labourers, these people choose to take land in tenancy. They could also rent lands if there are lots of family workers available to do the farm work. Moreover, if they take up the tenancy on lands, they could make their own choices, more easily.

5.4.3. The emergence of market gardening production

Between 1980 and 2000, boring number followed to grow, notably in zone 1. These borings allowed reducing the number of fallow land. In parallel, in 1989, government helped to create a cold store to store potatoes during summer season. Markets became more and more developed

and farmers had more opportunities to enhance the value of their products. Moreover demand increase with the population growth.

Some farmers who are living in zone 1 decided to grow more vegetables. They cultivated vegetables all year in high level lands. Equipment, type of soil and road proximity led this choice. They expected to increase added value of their products. Nevertheless to reach this goal they needed to work more. This production is mainly grown by farmers who have about 0,5 to 2 hectares and who rent a part of their lands. Indeed, most of them only have small lands and have to rent more. They rent lands in patta (fixed amount of money) and not in chaurha (fixed quantity of grain) because they want to optimize their vegetable production and they do not grow lots of grain crops. It is interesting to note that this area where market gardening emerge was less affected by migration.

5.4.4. Other modifications

As we have already seen, cultivated lands became more important (figure 36). Some landless appropriated some governmental lands. Except some farmers, the majority stopped to graze during rainy and winter seasons due to the expansion of cultivated areas. The number of bovines (oxen and milking animals) decreases. Indeed, just few farmers, who wanted to be independent, kept their oxen to plough the fields. Due to the less number of males, artificial insemination started to be used. Moreover, at that time, dairy sector was not developed in this block (contrary to the area near Patna where Sudha started its activity in 1983). So, the number of milking animals was not still higher.

Wheat became the second most important grain of the block. This brings about a change in eating habits. People start to eat chapatti, in addition to rice. Furthermore, the quantity of fertilisers increased, very few farmers still applied manure in their field.

Some landowners created brickyards. They used daily workers who wanted to earn cash money. The unattractive image of agriculture helped their implantation and development. At that time, some farmers also dug plots and created pounds to do fish farming. Furthermore, rich people tried to find techniques and systems to reduce the number of labourers hired.

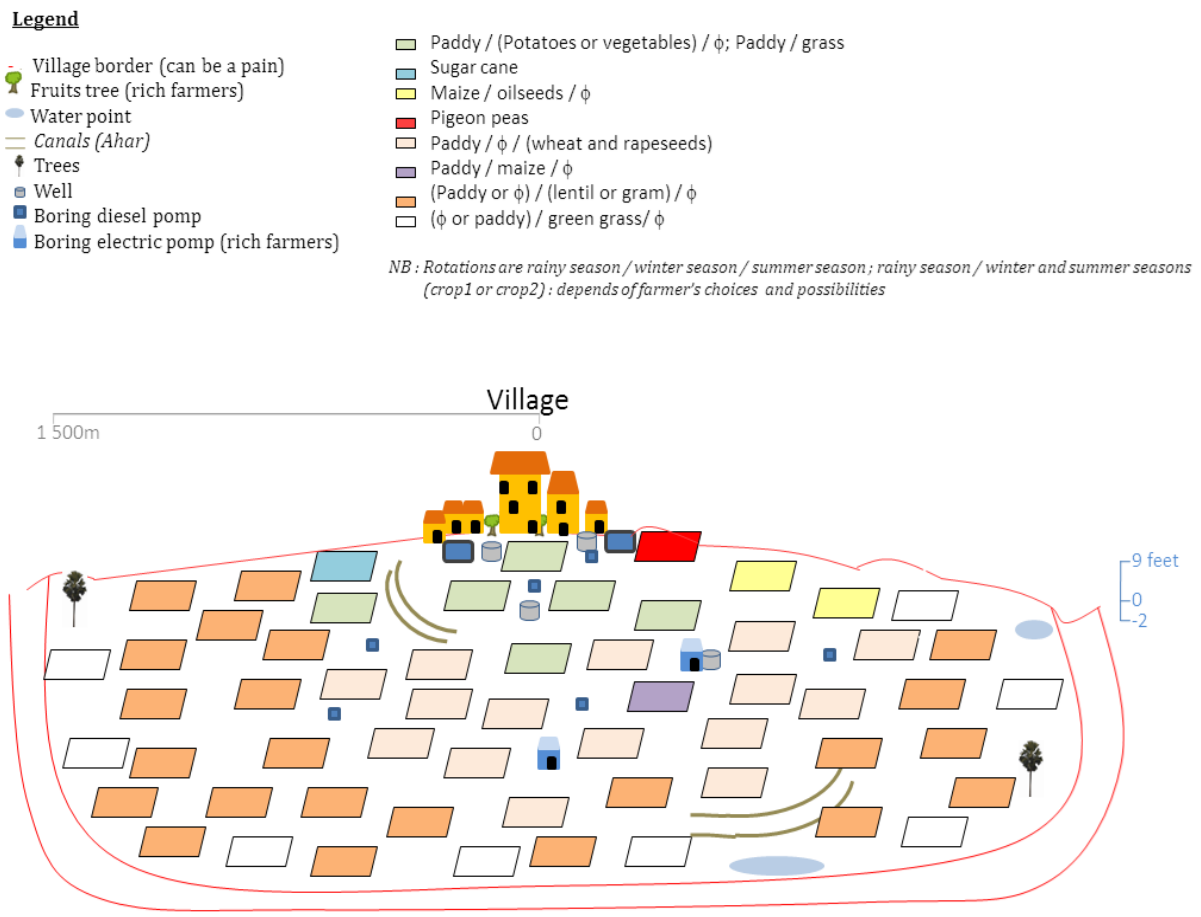


Figure 36: landscape between 1980 and 2000

5.5.Since 2000: Intensification of the Green Revolution and emergence of the White Revolution

5.5.1. Intensification of the Green Revolution

Since 2000, most of crops have remained the same in the Ekangar Sarai block. However, farmers have begun to use hybrid rice seeds. These hybrid varieties have a shorter production cycle, allowing an intensification of crops. Indeed, on a same plot, there could be as many as 3 crops per year. Moreover, hybrid plants have allowed reducing water intake and securing yields. As a consequence of the use of hybrid seeds, yields in Ekangar Sarai block became higher. For example, paddy yields were 2,4t/ha forty years ago and have increased to about 6,4t/ha.

The increasing use of outputs also led to improved yields. In 40 years, the amount of fertiliser applied per hectare has multiplied by ten. In Ekangar Sarai, the first fertiliser stores were opened at the beginning of the 2000s. An interview with a shop keeper told us that since then, the quantities of urea sold have gone up by a factor of two. For five years, the quantities sold are higher than at any point of the history. Their price has increased. For example, urea, produced in Uttar Pradesh was sold at 215Rs/50kg five years ago, and today it is sold at 320Rs/50kg. These values do not take into account inflation.

Furthermore, pest and disease pressure has increased, resulting in the use of pesticides and fungicides.

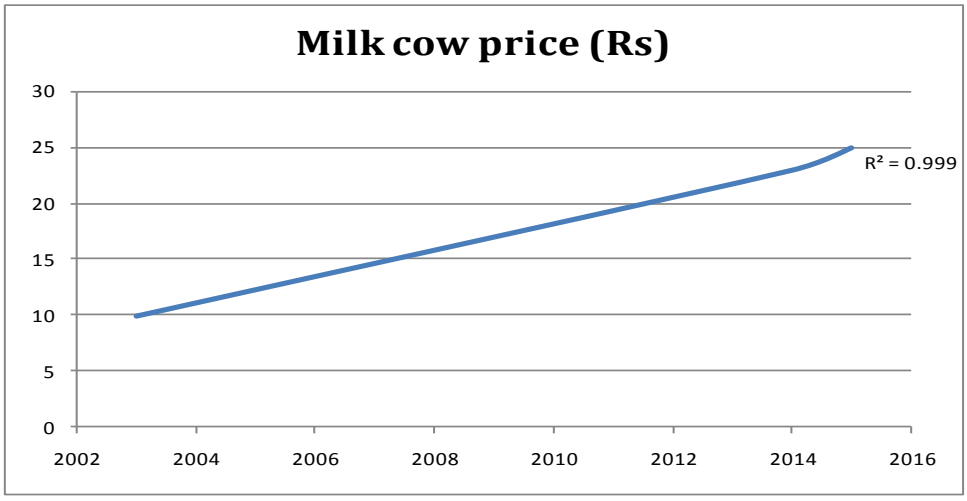
Wheat has become the second most important crop in the Bihar state, after paddy. Mechanization is increasing and combine harvesters are more and more used for wheat crop. Some of farmers become to have seeder, which can be combined (fertilization and soil working).

Today some greenhouses are present in the study block, they were vegetable nurseries. However, they have been used for two years.

5.5.2. A late White Revolution in boom

The White Revolution started with a dairy development program named Operation flood, launched in1970, which aimed to increase milk production and farmer income and provide fair prices for consumers. This program led to the creation of dairy cooperatives. In Ekangar Sarai block, the White Revolution is relatively late because development plans of Sudha cooperative are firstly initiated in the north of Bihar. For the last fifteen years, cooperative interventions have emerged in the study area. Furthermore, other cooperatives have tried to establish themselves in the block, in the last five years. However, the Sudha influence is such that the other cooperatives collapsed.

By providing high purchase milk price, Sudha has encouraged creation of milk collect centres in many villages. However, creation of collect centre depends on the wish of farmers, who want to diversify their activities and make profit. One farmer provides the necessary funding to the creation of the collect centre; he does not receive subsidies. Generally, a centre collects milk from about ten to hundred farmers, from 3 or 4 neighbouring villages. The purchase price depends on fat content assessed by equipment provided by the cooperative. In average, the collect centre purchases cow milk at 23Rs/L and the buffalo milk at 28Rs/L. Milk of all collect centres is purchased by Sudha at 25Rs/L for cow milk and 30Rs/L for buffalo milk. Since the creation of Sudha, the purchased price has increased (graph 6). Thanks to the creation of these collect centres, Sudha cooperative provides the opportunity for farmers to sell their surpluses, even in small quantities.

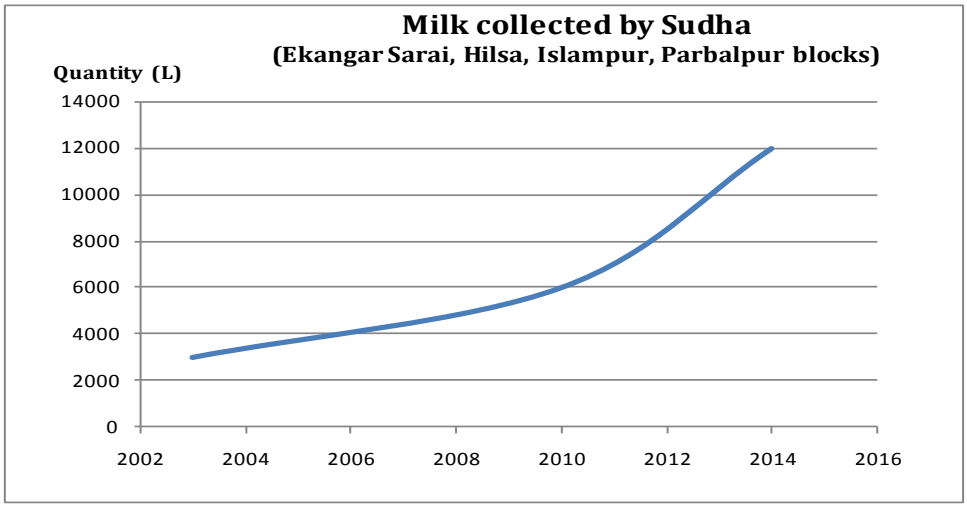


Graph 6 : Evolution of purchase price by Sudha dairy cooperative of cow milk (without taking account of inflation)

According to the condition of roads, an employee of Sudha can come to villages every day in order to collect the milk. In the most remote villages, farmers can sell their milk to villagers or to a middle man who sell it in local market. The milk collected by Sudha is transported to the Ekangar Sarai centre. This collect centre covers four blocks (Hilsa, Parbalpur, Islampur and Ekangar Sarai). Then, milk is processed and packaged in Patna. Dairy products are sold in big cities.

In the most populous villages, some big farmers (who have 7 to 8 cows) have chosen to be independent and to sell their milk to urban people.

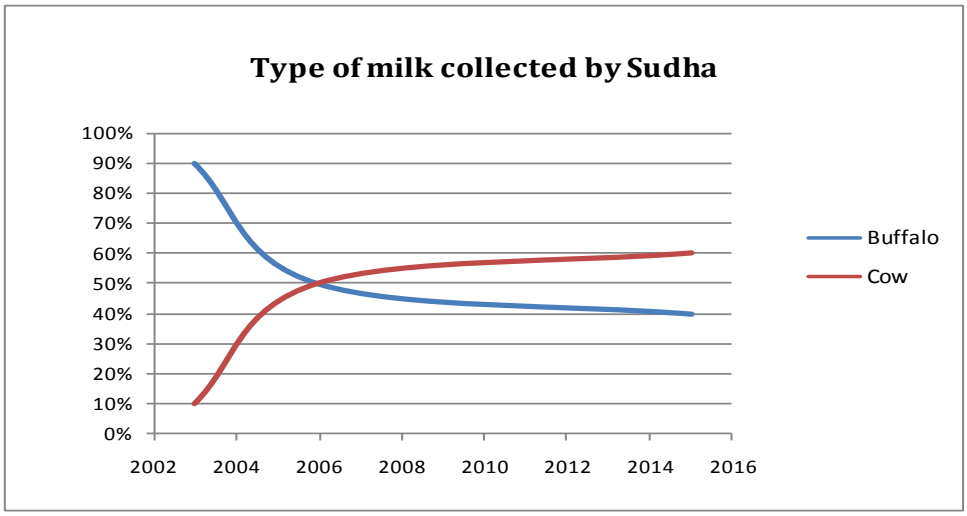
Since its creation in 2003, the centre in Ekangar Sarai collects more and more milk. At the beginning, it collected about 3 000L per day. In 2010, the quantities of collected milk amounted to 6 000L per day. For five years, the quantity has doubled again, to raise about 12 000L per day (graph 7).



Graph 7 : Evolution of quantities collected by the centre in Ekangar Sarai

When the centre was created, it collected more buffalo milk (90%) than cow milk (10%). Since 2006, the trend has reversed and today, 60% of collected milk comes from cows (graph 8). This increase of cow milk production is due to Sudha cooperative that has encouraged the purchase cows. These cows could be highly productive indigenous cows, like Sahiwal, or cross-breed cows. Sudha has given subsidies of 50% of the price. With the help of the subsidies, some farmers could increase their herd and their milk production. These contributions had to be preferentially allocated to small farmers. However, in this area, this does not appear to be the case, and few small farmers or landless have cross-breed cows.

In 2015, according to our observations in the field, there are more buffalos than cows in the block. Indeed, buffalos are hardier and can graze. So a large number of small farmers use to choose these animals. Buffalo production is lower and only surpluses are sold, which explains the small proportion of buffalo milk collected.



Graph 8 : Evolution of percentage of cow and buffalo milk collected in Ekangar Sarai centre

The cooperative has also developed its products:

- Concentrates, made of maize, soy, mustard, dry fodder and minerals. Its price is 800Rs/40kg and subsidies of 2Rs/kg are included in the price. The cooperative advises to give 400g per litre of milk produced.
- Minerals, sold at 150Rs/kg. Sudha advises to give 10g per litre of milk produced.

The development of milk sector is marked by the emergence of first highly productive cross-breed cows (Jersey or Friesian cross-breed), around 2005. Although the number of milking animals is still about 1 to 3 per farm, some farmers want to develop their dairy production. They have about 7 to 8 cross-breed cows.

As regards reproduction, there is a generalization of the access to artificial insemination, at the cost of 150Rs in average. However, some farmers in the most remote villages still use natural service.

5.5.3. Reorganization of market gardening production

In some parts of the block, the road network was improved and could offer facilities to farmers for selling their vegetables produced. In these areas, market gardening production increased again. However, in some other areas where vegetables were growing for selling, this production is now in decline. Two factors have affected the market gardening production. First, other market gardening areas are in competition with Ekangar Sarai block. Indeed, lots of vegetables come onto local markets of the block and compete with them. On the other hand, decrease of market gardening is due to the damage caused by the nilgai.

6. Production system description

6.1.Typology of production systems

6.1.1. Current farms

Understanding landscape and history allows gathering farms in different types. These farms characterize the study area. Evolution and development of each type result of the historic and biophysics factors.

6.1.1.1. Absent owner (Kurmi, Bhumiar)

As we have seen in the history part, some landowners have chosen to live in cities. They rent their lands to tenants or small owners. Moreover some other landowners living in villages and not interesting by agriculture rent also their lands. They have 4 to 70 bighas (1 to 17,5ha) and they use two contract types:

- Chaurha if they live in the village or in Bihar state. Tenants have to pay the rent with wheat or paddy grains. Owners are able to come back to take their rent (paddy and wheat).
- Patta if they live in other states. Tenants give money to a family member stay in the village.

6.1.1.2. PS1: Big grain farm with fish activity (Kurmi, Bhumiar, Brahaman, Mahuri)

Farmers live in villages and have 12 to 60 bighas (3 to 15ha). Their ancestors were zamindars who have kept a part of their lands or big and rich farmers. These big grain farms give 5 katthas (0.0625ha) to sharecroppers in order to gain some potatoes and onions which are to crops asking lots of work force. They adopt this practise in order to produce potatoes, onion and vegetables which need lots of workforce. Remaining lands are cropped by permanent workers completed by daily workers in function of needs. Owners organize the work and drive tractor. They also canvass different buyers. Moreover these farmers take parts in development and informative meetings, which show the innovations, new technics and new politics.. Most of the time, they are leaders of their villages and members of PACS. In some cases they use this power to obtain reciprocal concessions (better access to subsidies, find workers…).

These production systems have good equipment. They have 2 or 3 borings, one tractor, and all machines to be independent. One boring is near the house and protected by a small building. Electric and submersible pump is used to draw water. Other farmers can use this pump but they need to pay or exchange services. For 3 years some of them have bought a seed drill. They harvest half of their wheat with a combine machine. In order to do this they have to belong to PACS.

The main annual rotations are: paddy/wheat/fallow and paddy/pulses/fallow. Farmers use a big diversity of fertilisers (macro-elements, urea, phosphate, phosphorus, NPK…), seeds (hybrid and research) and pesticides. They also spray weed-killers. Since 2013 some farms have tried to reuse manure. They try to develop some agro-ecologic methods like intercropping, crop rotations. They are aware of the importance to preserve soils. They produce fodder all year long to feed one she-buffalo. This bovine also eats concentrates produced on the farm (paddy chaff, maize, vegetables, wheat flour, mustard press cake, etc). Milk and cooking dung cake produced

are only used by family members. They have chosen a she-buffalo because, according to them, milk taste is better the cow milk. Farmers have created pound where they breed fishes. They have chosen this activity because it does not need lots of workforce. Farmers have also teak trees and fruit trees which are sign of wealth.

Products are valued at best prices. They are not in desperate need of money that is why they can sell their goods when they want. They have buildings to keep products. Moreover more markets are opened to them. They can sell paddy to government, they have influence and can negotiate with middle man. Moreover farmers know laws and opportunities. So they can have access to subsidies.

Farmers' children study in big cities of the state. These teenagers hope became engineer and are not interested by farming. Therefore, it will be difficult to plan future.

6.1.1.3. PS2, big grain farm with dairy activity (kurmi, brahaman)

Five year ago, this production system was the same than the previous. However the White Revolution launched by Sudha opened a new market. They have invested in new buildings and 6 to 10 improve cows. Nevertheless they keep their grain activity. They sell milk to Sudha dairy cooperative and keep manure for their consumption. These farmers hope to develop their sector. They want to build their own collect centre.

Farmers have 10 to 40 bighas (2.5 to 10ha) and main rotations are the same: paddy/wheat/fallow and paddy/pulses/fallow. They use the same technical itineraries. Paddy is also sold to PACS. They feed their cattle with crop residues, fodder and concentrates buy in market (Sudha concentrates and mixture of maize and wheat flour) or produced on the farm (mustard press cake, wheat flour, etc).

They have same equipment that reminds their link with previous farms. A permanent worker takes care of cows and daily workers of crops.

Children study in developed cities and future is also opaque.

6.1.1.4. PS3, middle grain farm (Kurmi, brahaman, bhumiar, Yadav, Rajput)

Their ancestors were landowners, nevertheless land division between generations reduce land size. Today they have 5 to 12 bighas (1.25 to 3ha).They continue to plant grain crops. They hire daily workers and the owner just supervises works. They have less power than the previous farmers.

They have one boring built in old well and equipment to produce paddy. However they have not enough money to buy tractor, so they hire contractor. Nevertheless, some of them can have a tiller. They can use a combine machine to harvest one apart of paddy crops. The other part is harvested manually in order to preserve straw to feed cattle. They have two Sahival. These cows are fed fodder in winter and summer season. In rainy season owner increase the quantity of concentrates. Family members take care of these animals. Milk surplus are sold and dung cake used for cooking and fertilising field.

Main crop rotations are the same than previously. However farmers use only two types of fertilisers (urea and NPK) and no herbicide. Farmers belong to PACS and can sell their paddy to government even if their quantities are less important than the two previous systems. They can keep paddy to bargain their product but they have less power.

Children study in best schools of the block and one of them will replace father. Sometimes a family member has another work.

6.1.1.5. PS4: middle vegetable farm (Kurmi Mahto, other Mahto)

Their ancestors were landowners like farms of production system 3, nevertheless land division between generations reduce land size. Today they have between 4 to 7 bighas (1 to 1.75ha). They belong to Mahto caste. They plant vegetable because they are in zone 1. They grow vegetables all year. Around 30% of land is planted in vegetables during winter season. They hire permanent workers to help them in their labour. They increase their vegetable production between 1980 and 2000. However today, lack of workers, environmental issues (nilgai) and supply decreasing prevent them to plant more vegetable.

Like the other production systems, they have a boring and equipment to produce paddy. They use fertilisers (urea, NPK). They have, like production system 3, two Indian cross-breeds fed similarly. They use hybrid and research seeds in order to increase yield and reduce growth circle.

Children study in the best schools of the block.

6.1.1.6. PS5: middle dairy farm (Yadav, Kurmi)

Their ancestors reared cattle. They captured land at the end of zamindari system. Today they have between 4 to 7 bighas (1 to 1.75ha). They also have 4 improved cows. They sell milk to Sudha cooperative and manures are used like manure in field or to cook. Yadav people are less powerful in Ekangar Sarai than in other block like Bodhgaya. As a result, they do not participate in lots of meeting. They are marginalised. Cattle number increases after Sudha installation. However, even if these farmers want to have more animals, they cannot buy new. Moreover cattle are sold according to needs.

This production system crops fodder and maize to feed cattle. However, grain crops have a big share in gross income. They also plant some vegetable for their self-consumption. Two family members work on the farm. They are helped by daily workers. They have basic equipment, boring, and small thresher. They use fertilisers and buy seeds in market. The financial needs are important, that entails the sale of goods few days after harvest.

Children study in schools of the block. Sometimes farmers have dairy collect centre to earn more money.

Some farmers prefer to have 3 buffaloes. These buffaloes graze in summer season.

6.1.1.7. PS6 small gardening farms (Scheduled cast)

Farmers were landless before independence. They were workers or tenants. After the independence they captured few lands, 0,5 to 1 bighas (0.0625 to 0.125ha). Today they also rent lands to complete their small plots. This production system, like the production system 4, is located in the zone 1. In order to increase their added value they plant vegetables. Two family members work all the days on lands and take care of the buffalo. This animal produce milk and dung are used to cook. Milk surpluses are sold. They hire daily workers according to needs. Farmers are absent of meeting and PACS. They are marginalised and they do not want to speak with authority because they are afraid to be cheated.

Vegetable are planted all year. In winter and summer seasons, 60% of lands are covered in vegetables. Remaining lands are seeded in grain to feed the family and cattle. They sell their vegetables to middle men. Middle men come and take vegetables. Farmers buy seeds in local market. They use fertilisers and pesticides according to advices of shop sellers.

Most of the time, farmers have no boring. They buy water from rich farmers. They rent equipment to thresh paddy. They have only little instruments. Children study in governmental schools. They help their parents according to needs. Most of the time children graze with the buffalo. When children will become adult they will work with their father in fields.

Some of farms belonging to this production system have their own boring.

6.1.1.8. PS7: Small grain farm (scheduled cast)

Their ancestors were tenant or workers. Like the previous system (PS 6), they captured some lands after 1947. Today, after division they have 10 to 20 katthas (0.125 to 0.25ha). They rent two to four bighas (0.25 to 1ha). Rents are paid in grains. As a consequence, farmers do not have choice and they have to grow grains. Most of the time, they have some discrepancies with powerful people, so they cannot have good lands. They just have low fertile lands (some years they cannot plant anything on some plots). Moreover they are not sure to have land the next year. Farmers, like those of production system 6, are marginalised. Farmers do not know when meetings happened, what PACS offer, etc.

They do not have boring or any equipment to produce grain. They rent all the equipment. They have difficulties to bargain good prices for their surpluses. They need money, so they do not have choices. Just after harvest they sell products. At that time market prices are lower. Farmers cannot plant any crops during summer season. They have no water or enough money to grow something. Moreover, contracts start in May and finish in April, so if contracts are not renew farmers lose their crops. That is why farmers do not sow any crops during summer season.

Farmer use residues of grain crops to feed their buffalo. This buffalo grazes during summer season. Farmers give also concentrates when they have enough money. They also have two hens for self-consumption.

Most of the time children help their parents according to needs. Sometimes they do not go to school because they have to work on the fields. One of parents works in the family shop.

For 3 years, contracts change. Farmers have no good yield so they cannot pay rent. After discussion with owners they decide to share the harvest.

6.1.1.9. PS8: Small grain farm + daily worker

Their ancestors were daily or permanent workers. Today they are landless and they hire some lands, 1 to 2 bighas (0.25 to 0.5ha). In order to have cash money to buy seeds and fertilisers, they are also daily workers for big famers during harvesting and transplantation times. They have relation with big owners, so these owners give to them fertile lands when they rent lands. Exchanges with big farmers allow them to know new practises and new inputs.

They exchange work to have water and equipment to thresh grains and pulses. They have, like the two previous systems, one buffalo. Dejections are used to cook and milk surpluses are sold. They have two hens to eat meat. They apply few pesticides and no herbicides on their plots. Family workers work on this production system.

Children study in governmental schools and help their parents according to needs.

6.1.1.10. PS9: workers (scheduled castes and some forward castes)

Workers belong to different castes. Most of the time, they are come from scheduled caste but not only. Workers can also come from backward caste. All of them have animals. However types of animals depend on the financial capacity. Most of the time one part of the family lives in another state in order to earn money. If man goes to another state to find job he can come back during rainy season to help the family. In the Ekangar Sarai block there are four types of workers:

- Daily workers who are landless, and have a buffalo (48%),
- Daily workers who are landless and have goats (20%),
- Daily workers who rent some lands (30%), we have presented them before (PS8)
- Permanent workers (2%).

Daily workers earn goods during harvesting and threshing time, and they earn money during transplantation time or for the other activities. Permanent workers earn fixe salary. Moreover owners pay them food and sometimes lodgement. Women workers earn less money than men. It is landowners who recruit workers.

6.1.1.10.1. PS9a: daily worker with buffalo

They are landless and work for other people. They do not have enough money to buy seeds or fertilisers that is why they cannot rent some lands. They have one buffalo which graze when lands are fallow. They sell milk surpluses and keep dejection to cook. Men and women can work. Some men go a part of a year to other states to work. Women take care of buffalo and work during harvesting and transplantation time. Children study in governmental schools. Some of these workers have a cross-breed cow. One big farmer has given the cow. Worker takes care of the cow until the calving. Owner rebuys the cow (half of the normal price) and workers can keep the calves (or buy).

Some buffaloes graze all year.

6.1.1.10.2. PS9b: daily worker with goats

It is the same production system than the previous. However farmers are poorer and cannot buy a buffalo. Women have goats in order to supplement their incomes. Children look after goats during week-end and vacations. Kid goats are sold to middle men.

6.1.1.10.3. PS9c: permanent worker

Wage are same than the two previous systems. However landowners give 10 katthas (0.125ha) to workers. On this plot they seeds grain and vegetables. Yields are poor because they do not have time to take care of their lands. They are exploited by landowners. Landowners can call workers when they want because they have given 10 katthas. Workers accept this situation because landowners represent a security. For example if they want to marry their daughter, landowner can help them to pay dowry.

6.1.1.11. SP10: Shepherd (Gaderia)

Most of these farmers are landless. They graze 8 hours on fields. During rainy and winter season they graze in canals and road sides. 60 animals compose a herd. Farmers sell ghee, wool and dejection. On the last point, shepherd sleep with their herd on field in order to fertilise them. Farmers have to pay them. In the past, they have been in high demand to fertilise crops. 50 years

ago, in some village there were 13 herds. Today they are only 4. Shepherds follow their work because it is a tradition.

Births happen between November to December. Lambs are sold at the age of 4 months. However shepherd keeps also some males which are selling at the age of 2 years. Middle men come to take animals. Mortality rate is very high during dry year. Calving rate is around 0.7 lamb per ewe.

6.1.2. Origin of types

We try to resume this point in the following scheme (figure 37).

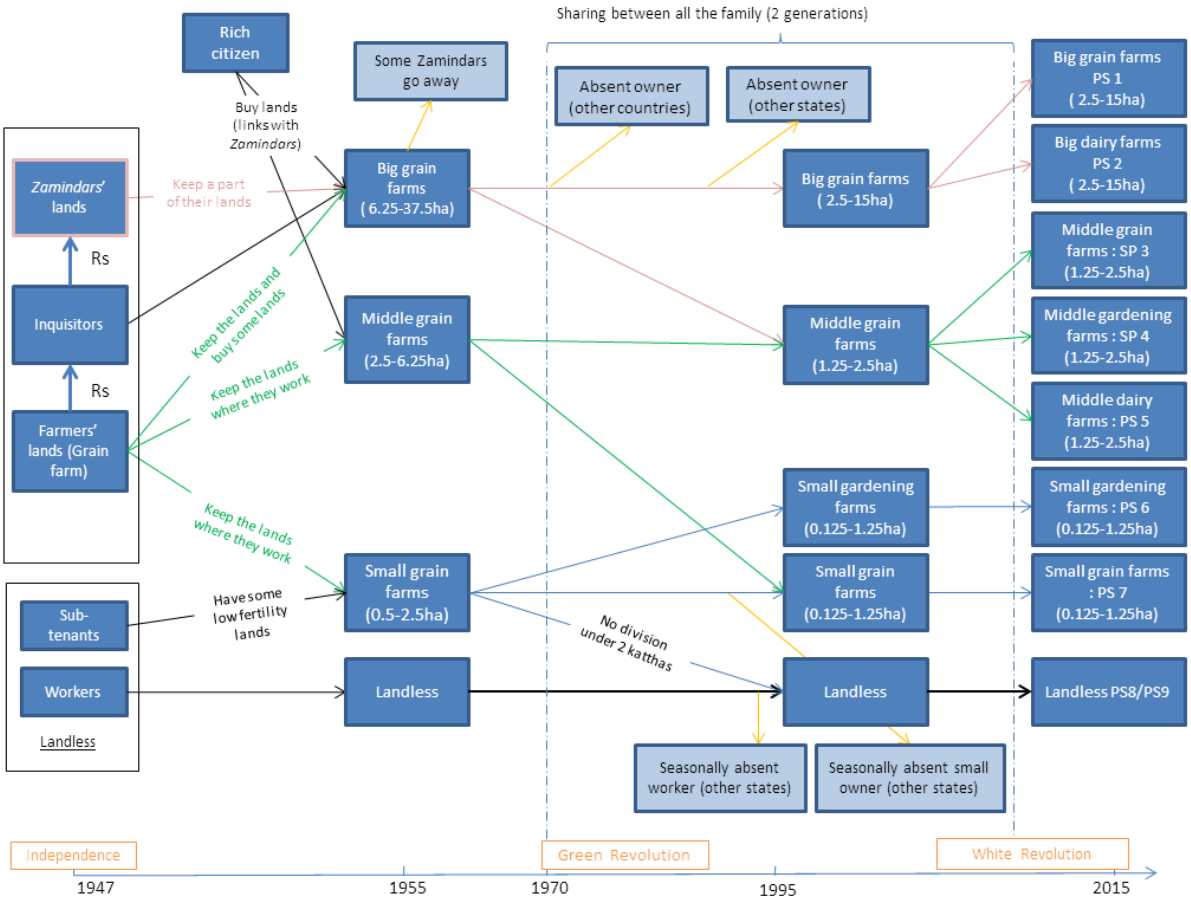


Figure 37: origin of types

5.2.Cropping systems

Before presenting each types of cropping system here there is a table summing the crop growing period (figure 38).

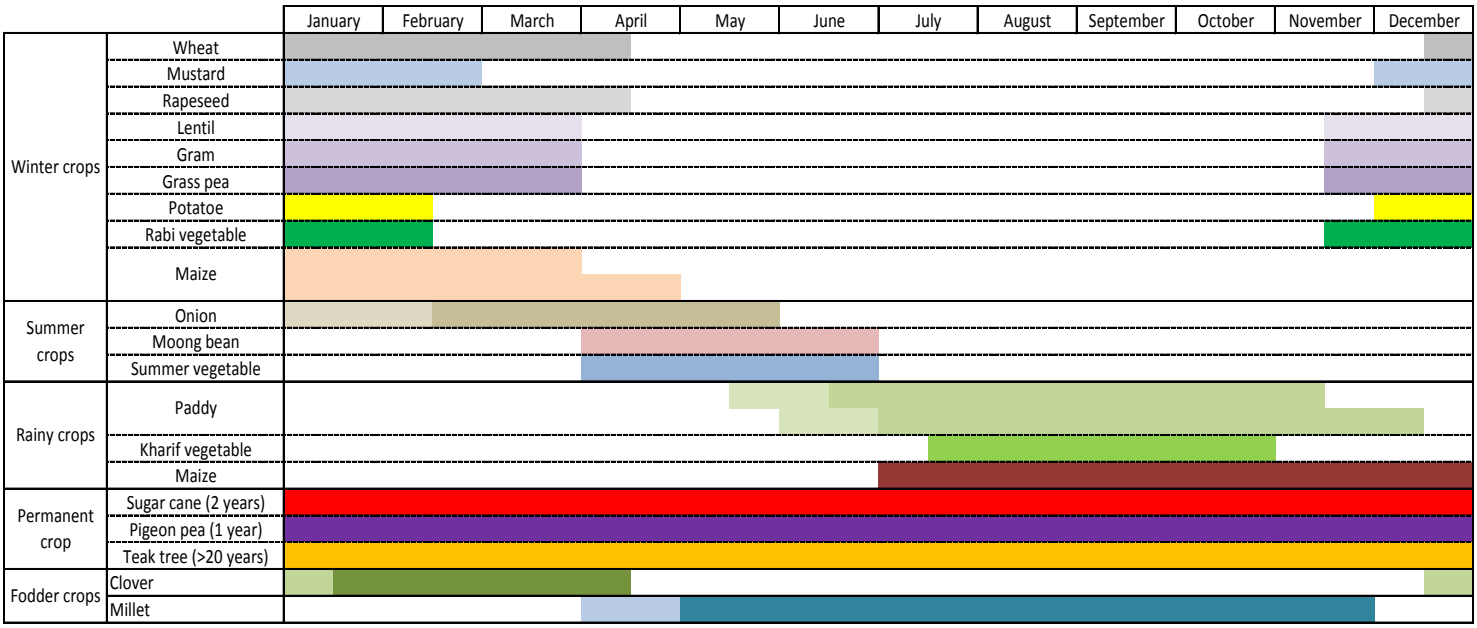


Figure 38 : Crop growing period. In lighter colour, it is nursery period.

5.2.1. Crop intensification

Excepting annual and multiannual crops, most of farmers plant 1 to 3 times their plots in a year. For twenty years we have noted crop intensification in the form of an increase in crops growing per year. However, there is a disparity within areas. Plots which are near the houses are grown three times, whereas some plots far away from farms and which are not irrigated in winter season or flooded in rainy season, are cropped only one time. Overall plots are planted 2 times. These plots are fallow during summer season.

In the study area, there are few interannual rotations. Indeed, from year to year, except in some farms, farmers plant same crops in same fields. They do not use this practice in order to renew soil fertility or to limit pest and disease pressure. An exception can be noted as regards sugar cane. This crop is not grown again in the same plot for two years ([sugar cane] ^{2}// [paddy/wheat/∅] ^{2}).

5.2.2. Description of cropping systems

Some cropping systems do not have references. That means we just mention them in the following part but we do not reuse them in production system description. Each cropping system is presented by an annular calendar. On this calendar readers can find different information like fertilisers quantity, yield, selling price, herbicides, description about operations… These calendars are available in annexe. An example is presented for the rotation paddy/lentil/fallow.

5.2.2.1. The main crop: paddy

One of the predominant crops is the paddy crop, growing during the rainy season. It is the pillar of a lot of cropping systems met in Ekangar Sarai block. Farmers use hybrid (40%), local (20%) or research varieties (40%). In the same year, one farmer grows two to three different varieties.

Twenty years before, one farmer planted more varieties. However the lack of workers often leads to decrease the number of varieties grown. Indeed, it needs more time and workers to grow several types of paddy. Each paddy has to be treated separately. Farmers use different types according to the next crop and water availability. On the plots where lentils and grams will grow during winter season (in zone C), farmers transplant hybrid varieties of paddy. These varieties have a 15 days shorter growth cycle. Thus, pulses will be planted before wheat and use the residual moisture to grow. Moreover, hybrid variety is greater resistant to humidity variations (flood and drought). Before wheat, all the types of paddy crop could be planted.

Hybrid varieties of paddy are more expensive and need more sanitary treatments. Research seeds seem to provide the best yield. Their price is intermediate between hybrid and local varieties. Local varieties still maintain a strong presence in the block (about 20%).Their taste quality and hardiness explain this fact.

Paddy rice is sowed in nursery during the month of June. It is transplanted a month later, in July. During the nursery stage, fertilisers are applied at seeding and irrigation time. Just before the transplantation, plots are flooded, and ploughed a few days later. This step is done for all crops and acts as a stale seedbed. During the transplantation, fertilisers are applied again on paddy crop. Then, farmers fertilise 2 to 3 times their fields. Some farmers fertilised less varieties which grow after legume crops. Irrigation can vary from year to year, according to the quantity and frequency of rainfalls. In a normal year, farmers used to irrigate 4 times the paddy crop.

Although farmers are not able to identify pests and diseases, they generally apply pesticides and fungicides. The richest farmers use to apply herbicides, one month after transplantation. The other farmers weed their fields manually. Herbicides allow limiting the number of hand weeding. Paddy is most of time harvested by hand in November or December. Farmers use daily workers. Just after paddy is harvested, farmers plant winter crops. Thus, they defer the threshing from one to two months. In order to maintain paddy, farmers make bundles (*puol*) which are joined to form *pinj* (figure 39 and 40). The threshing and transformation of paddy is mainly done manually (figure 41 and 42). However, a share of the harvest can be threshed directly by combine machine. Straw is used as feed for animals. In case of surplus, they can also be sold. A contractor comes to collect them[17] (figure 43).

Figure 39 : Puol

[17] Appendix B

Figure 40 : *Pinj*, made with *puols*

Figure 41 : Manual threshing of paddy

Figure 42 : Transformation of paddy

Figure 43 : Collect of paddy straw

5.2.2.2. Cropping systems including rice

5.2.2.2.1. Cereals and pulses

5.2.2.2.1.1. CS 1 | [Paddy/∅/∅]⁴// [∅]⁴

CS1

In rare case, this cropping system is practiced by the poorest farmers. The lack of financial resources and irrigation prevents them to grow crops. Moreover some of them go to other states to find a job, and they only come back during paddy crop.

5.2.2.2.1.2. CS 2 | [Paddy / Grass pea /∅]

CS2

This cropping system is located in zone C, far from borings. Middle and small farmers realize this annual rotation. Big farmers are not interested because other crops are more cost-effective. Grass pea crop (*Lathyrus sativus)* is sowed before the harvest of paddy crop. The water resistance of seeds enables this process. Moreover this crop is grown on clay soil plots, which hold moisture and are far away from houses, for two reasons. Remaining moisture is enough to growth of grass peas and this crop do not need lots of operation (fertilization, treatments…). However these plots are most of time in low level lands. Grass peas tolerate also high level of moisture.

Grass peas are not sold. Farmers use it for self-consumption or in cattle diet. They hire contractor to split grain and straw[18].

5.2.2.2.1.3. CS 3 | [Paddy / lentil /∅] or [paddy / gram/∅]

CS3

The cropping system is found in the same area than the previous one. Lentil and gram are sowed following a ploughing, after the harvest of paddy. The remaining moisture enables the seeds germination. If there is a lack of moisture, farmers can irrigate the plot before seeding. However, lentil and gram are sensitive to excess of water. If there is lots of rainfall, crops could be damaged. Lentil and gram are fertilised one time, during seeding. Plots are treated 2 to 3 times with pesticides. Like grass pea, harvesting is carried out by hand. In order to limit weed pressure, farmers do not implement specific practices. However, farmers who do not grow fodder can weed plots of other farmers to feed their cattle. There are three varieties of lentils: the small, the sweet, and the strong.

Lentils can be associated with mustard. The length of the cultivation cycle of these two crops is the same. In cold years, mustard can protect lentils. Small farmers use this practise to dispose of the maximum number of goods.

Most of the time farmers keep lentils for their self-consumption. However some of them (big farmers) sell surpluses to middle men. Big farmers have a small thresher to split grain and straw. Other farmers hire one. Straw is sold to middle-men.

An example of annual calendar is presented below (figure 44). Annual calendars of each crops are provided in appendixes.

[18] Appendix C

		Quantity (kg) /ha	Rs/ha	January		February		March		April		May		June		July		August		September		October		November		December	
Paddy (C1)				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Products		48q	74880																								
Co-products		8000 puols	8800																								
Nursery	Plowing	oil = 1L	56										0.25														
	Irrigation	56m³	200										0.88		1	Flouding											
	Seeding	20kg	5000											0.05	Hybrid seeds												
	Weeding														3												
	Fertilization													0.01	0.01	Urea											
	Pesticide													50% DAP	4												
	Harvesting													+50% Urea		4											
Seeding preparation	Plowing	6 times (20L)	1120												1.5	Tractor											
	Soil working															2	Division of the plot to improve irrigations										
	Irrigation	320m³	2000												1												
	Transplantation															40	Transplantation by women										
Weeding		1.2L	3600														15	Manualy + Weed killer	25	Manualy							
Irrigation		1280m³	8000															1	1		1		1				
Fertilization		600kg	7968													2	33% DAP	2 Urea									
Pesticides		1.6L	640														+33% Urea		2	against stemborar	2	against harda					
Harvest	Cuting																+33% Macroelements							35	Creation of puols		
	Creation of puol																							12	Creation of pinj		
	Threshing	oil = 19L	1075.2		32																						
	Bagging + selling						4																				
Total paddy				C1	GI	83700	Rs			IC	29700	Rs					GAV	54000	Rs		0	Work	189	Days	0	12,8q	
Lentils (C2)																											
Products		12,8q	61440																								
Co-products		12q	2160																								
Seeding preparation	Plowing	6 times (20L)	1120																						1.5		
	Soil working																								2		
	Irrigation before seeding																										
	Transplantati	Sweet 80kg	6000																						0.75		
Weeding																											
Irrigation																											
Fertilization		DAP 120kg	3000																						2 DAP		
Pesticides		2L	800		2	against ghangara																					2
Harvest	Cuting							20	Manually																		
	Creation of bundel							7	Transport to the house																		
	Threshing	oil = 16L	896						20																		
	Bagging + selling											12	drying														
Total lentils				C2	GI	63600	Rs			IC	11800	Rs					GAV	51800	Rs			Work	70	Days			
Total C1+C2					**GI**	**147300**	**Rs**			**IC**	**41500**	**Rs**					**GAV**	**105800**	**Rs**			**Wor**	**259**	**Days**			

Figure 44: annual calendar rotation paddy/lentil/fallow

5.2.2.2.1.4. *[∅/lentil/∅]*

This system is found in zone A, on high points far from houses. It differs from the previous system in that paddy crop cannot grow in this area. Indeed, on high points, water percolates and there is a lack of adequate soil moisture for paddy crop.

5.2.2.2.1.5. *[Paddy/maize/∅]*

This system is carried out in zone B, near the houses. Maize has 3 to 4 months-cycles. Maize is sowed in January and harvested manually in April or May. It needs two fertilisations. Most of the time, farmer seeds are used. Maize is used to self-consumption and to feed animals. Before maize all paddy types are able to be planted. This rotation is only done by big farmers.

5.2.2.2.1.6. *CS 4 | [Paddy/wheat/∅]*

CS4

This is the most common cropping system in the block. It is mainly found in zone B, and sometimes in zone C. The two crops have complementary cycles. Indeed, wheat is sowed in December, just after harvesting of paddy. Moreover these two crops look like essential for Bihari people. They are base of Bihari diet and they allow landless to pay their rents.

Like paddy, there are several varieties of wheat (local and research). Although research seeds have better yields, some farmers prefer local varieties, which correspond better to their taste expectations and which are more resistant. Wheat is sowed during ploughing, one week after irrigation. Farmers plough their fields twice, a first time in the length, and the second in the width. Seeds are broadcast between the two ploughing. During the second ploughing, a piece of wood is linked to the tractor in order to level the soil and break clods (figure 45). Following this step, farmers fertilise their plots. Two fertilisations are generally carried out, one during the second irrigation and another one during heading. The richest farmers apply pesticides. They also spray herbicides, during the first irrigation, one month after seeding. This spraying allows limiting the number of hand weeding. However, they hire once workers or landless which carry out the grass. These labourers are daily paid and keep grass to feed their cattle. Other farmers do not use to weed their plots.

Figure 45 : Soil levelling after seeding

The harvest is done in April. For three years, the richest farmers have rented a combine-machine to a contractor (figure 46). Nevertheless the harvest with combine machine is disorganised. Lacks of space and rented tractors impede the harvest. If farmers want to harvest their wheat with a combine machine they have to belong to the PACS. PACS and village leader organise the harvest. Disgraced farmers meet some problem to harvest their wheat. Most farmers burn straw remaining on plots (figure 47). The other farmers harvest wheat manually (figure 48). All farmers rent a big thresher in order to separate the wheat from the chaff (figure 49). Crop residues are used to feed their cattle. Surplus straw can be sold. Grain is sold to middle-men. PACS does not buy wheat.

Figure 46 : Combine machine in order to harvest wheat

Figure 47 : Burnt plot after wheat harvesting

Figure 48 : Manual harvesting of wheat

Figure 49 : Wheat threshing after manual harvesting

Wheat can be associated with rapeseed. This association is mainly carried out by farmers who harvest wheat manually. This association:

- Makes possible to obtain two products with space optimisation.
- Allows protecting wheat from nilgai damage, when rapeseed grows on the edges of field.
- Allows protecting wheat from diseases.

Thus, these last two points suggests that this association can also be used by farmers who harvest a part of wheat with combine machine. However, they have to harvest rapeseed before the harvest of wheat[19].

In this rotation there is no crop during summer because:

- Wheat is harvested latter
- Wheat and paddy need more nutrients. Therefore no more nutrients are available.

5.2.2.2.1.7. *[Paddy/wheat/∅]//[paddy/lentil/∅] or [paddy/gram/∅]*

Some farmers carry out this cropping system in order to insert more legume crops in their rotations. Generally, it depends on water availability. During dry years, pulse crops will be preferred. Similarly, in case of money issues, legumes are also chosen. This cropping system is mainly found in low level points. Legumes allow fixing nitrogen into the soil. Farmers who do this rotation have better yield for paddy.

[19] Appendix C

5.2.2.2.1.8. *CS 5 | [Paddy/lentil/moong bean]*

CS5

This cropping system is an intensification of [paddy/lentil/∅]. After the harvest of lentils, plots are irrigated. Then, moong bean is broadcasted during ploughing, after a soil levelling (figure 50). This crop is fertilised twice, first at seeding time, then during the first irrigation. Some farmers can apply pesticides on this crop, but no herbicides are sprayed. Moong beans are harvested 3 to 4 times. Moong bean grows preferentially after lentils because this crop is harvested earlier than wheat. Moong bean is used for self-consumption[20].

Figure 50 : Broadcasting of moong seeds

5.2.2.2.2. Cropping systems including vegetables or forage crops

5.2.2.2.2.1. *CS 6 | [Paddy/clover/∅]*

CS6

This system grows in zone B, near the houses because harvests of fodder are frequent. Clover crop is sowed at the end of December or at the beginning of January. It grows on plots divided into compartment allowing flood irrigation. In normal year, this crop is irrigated about 5 times and fertilised at seeding time. Clover crops are frequently infested with grasshoppers. Farmers used to harvest clover a maximum of five times. Clover fixes nitrogen in the soil. Farmers have noted that paddy crop yields are better after clover. This rotation is used by farmers who have cattle and enough lands. Small farmers who have cattle do not use this rotation. They prefer to do other rotation more cost efficient or used for self-consumption.

CS7

[20] Appendix C

5.2.2.2.2.2. *CS 7 | [Millet/vegetable/millet] or [millet/potatoes/millet]*

This system is found in zone A, close to the houses for the same reason than previously. Millet is broadcasted at the beginning of August and at the beginning of April. This crop is growing during 3 months, there are five harvests. At seeding time, farmers fertilise millet plots. At the early stage of development, farmers weed their plots manually. Millet can resist to flood.

Potatoes are sowed in December and harvested in January or February. There are several varieties of potatoes (Pukhraj, Patna red, Bengal jyoti, etc). The red varieties have a lower yield, they are self-consumed. Before seeding, big potatoes are cut in five, small potatoes are cut in maximum two. Each piece has a germ. This practice prevents the exhaustion of resources during the germination, and allows better yields. Fertilisers are applied twice in large quantities. The first fertilisation is carried out at seeding time, the second during the hoeing, one month later. Potatoes need also three pesticide applications. Farmers keep one part of harvest for self-consumption. The other part is sold. Small farmers sell their potatoes after the harvest. Big farmers keep their potatoes in cold store and sell them in October. At that time prices are higher.

Most farmers who have cattle and lands grow one katta (0.0125ha) of fodder per adult animal. Fodder can be consumed fresh and cut.

Apart from the poorest, farmers (PS 1 to 5) grow these two complementary cropping systems in order to feed their cows or buffalos during nine to ten months. During April, August and December, named transition period, animals are fed with grass cut in the fields.

5.2.2.2.2.3. *CS 8 | [Paddy/potatoes/onion]*

CS8

After the harvest of potatoes, plots are ploughed. Then, plots are divided into compartments, allowing flood irrigation (figure 51). Onions are sowed in nursery in January and transplanted in compartments, about a month later (figure 52). This crop requires lots of irrigations, inputs of fertilisers and pesticides. It requires also two to three manual weed controls, during the first two months of growth. Onions are harvested in May. Thus, they can grow between potatoes and paddy crop.

Figure 51 : Levelling of plot after the creation of compartments

Figure 52 : Transplantation of onions

This system is carried out in zone B, close to the houses. Indeed, onions require soils which keep a bit of water. So, they grow well on intermediate soils. Moreover, potatoes and onions need lots of interventions, that why they are preferentially planted not far from villages[21].

5.2.2.2.2.4. *CS 9 | [Paddy/potatoes/maize]* CS9

We find this system in zone A, on high level points. Maize, growing during summer season, is sowed in March. At that time, only potatoes are harvested. As a result, maize grows after this crop. Moreover, these two crops have better yield when they are planted on sandy soils. Maize is harvested in June or July. Maize feed cattle (80%) and human[22].

5.2.2.2.2.5. *CS 10 | [Paddy/potatoes/vegetables]* CS10

This system is found in zone A, on the nearest plots from the villages. It allows looking after sought-after products. The soil type prevents the spread of diseases and yield loss. Indeed, on sandy soil, water percolates and thus, moisture is not so high. However, these plots require lots of irrigation. Vegetables plots are the most frequently fertilised and sprayed. The richest farmers apply fertilisers after the first three irrigations. The others apply them once or twice. Pesticides can be sprayed three to five times. These crops also require lots of manual weeding.

During summer season, we can find cucumber, ladies' finger (*Abelmoschus esculentus*), pumpkin, biter gourd (*Momordica charantia*) and Egyptian cucumber (*Luffa aegyptiaca*). Before the sowing of all these vegetables, farmers carry out a manual false seed-bed[23].

5.2.2.2.2.6. *CS 11 | [Paddy/vegetables/vegetables]* CS11

This system is located in the same area than the previous system.

During winter season, tomatoes, cauliflowers and eggplants can grow on these plots. Before being transplanted, plants are done by farmers.

During summer season, the same vegetables than in the previous system grow.

These systems are labour-intensive. They are grown for self-consumption by most farmers. However, some of them cultivate vegetables in large quantity in order to sell them.

5.2.2.2.2.7. *CS 12 | [Vegetables/vegetables/vegetables]* CS12

This system requires lots of workforce. It is found in the vegetables production area (zone 1), on high level plots (zone A), near the houses. Farmers living in the other zones can done this system in very small quantities, for self-consumption[24].

5.2.2.2.3. Cropping systems especially on high level plots

5.2.2.2.3.1. *CS 13 | [Maize/mustard/∅]* CS13

We find this system on high level points (zone A). Indeed, mustard crop consumes less water than wheat. It requires only irrigation once. Thus it is adapted to these draining soils. It has a three-month cycle and it is harvested at the end of February or beginning of March. Seeds are

[21] Appendix C
[22] Appendix C
[23] Appendix C
[24] Appendix C

pressed to make oil, used for cooking or used as body care product. Mustard press cakes are used to feed cattle, and straws are used as fuel.

As regards maize crop, it requires a lower level of moisture than paddy. But on sandy soils in zone A, water percolates. Thus, paddy crop is not adapted to these plots, and farmers choose to grow maize. This crop differs from maize growing during winter season. Its cycle takes six months[25].

5.2.2.2.3.2. *CS 14 | [Pigeon pea]*

CS14

This cropping system grows on the highest plots (zone A') (figure 53). This annual crop does not require irrigation or other inputs. Seeds are sowed at the beginning of June, after a ploughing. In March, shrubs are cut in order to harvest the peas[26].

Figure 53 : Pigeon pea (above) grow on the highest plots

Some farmers plant these shrubs on the edges of plots in order to save space.

5.2.2.2.4. Cash cropping systems

5.2.2.2.4.1. *CS 15 | [Sugar cane] [2]// [Paddy/wheat/∅] [2]*

CS15

In the past, this system was very widespread. Nowadays, it is grown by only a few farmers, who are relatively wealthy and who want to have their own juice. Sugar cane is biennial, but a cutting takes place at the end of the first year. A minimum of two years must be allowed to elapse before grow sugar cane again. This delay allows limiting pest and disease pressure. Sugar cane is sowed at the end of the rainy season[27].

[25] Appendix C
[26] Appendix C
[27] Appendix C

5.2.2.2.4.2. *CS 16 | Teak tree*

CS16

These trees, well exploited, require a minimum of interventions. Every year, fertilisers are applied once. Trees are cut after a 20 to 30-year growth cycle. Farmers who plant these trees must have an important amount of capital. Thus, only the richest farmers grow this system.

5.2.2.2.4.3. *CS 17 | Mango tree*

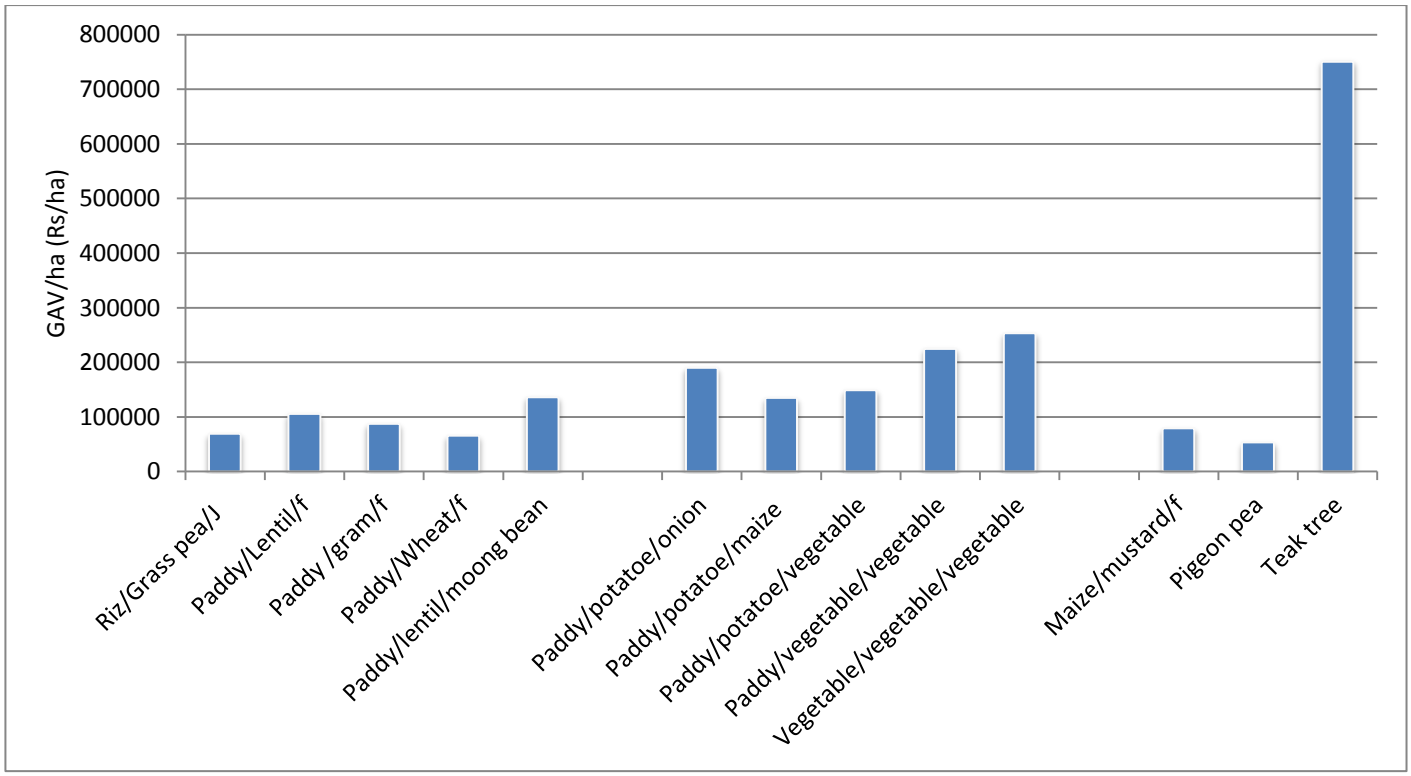
CS17

The richest and most powerful farmers have always some mango trees for their self-consumption. These trees are a sign of wealth. Mango trees are usually irrigated.

5.2.3. Comparative analysis of cropping system

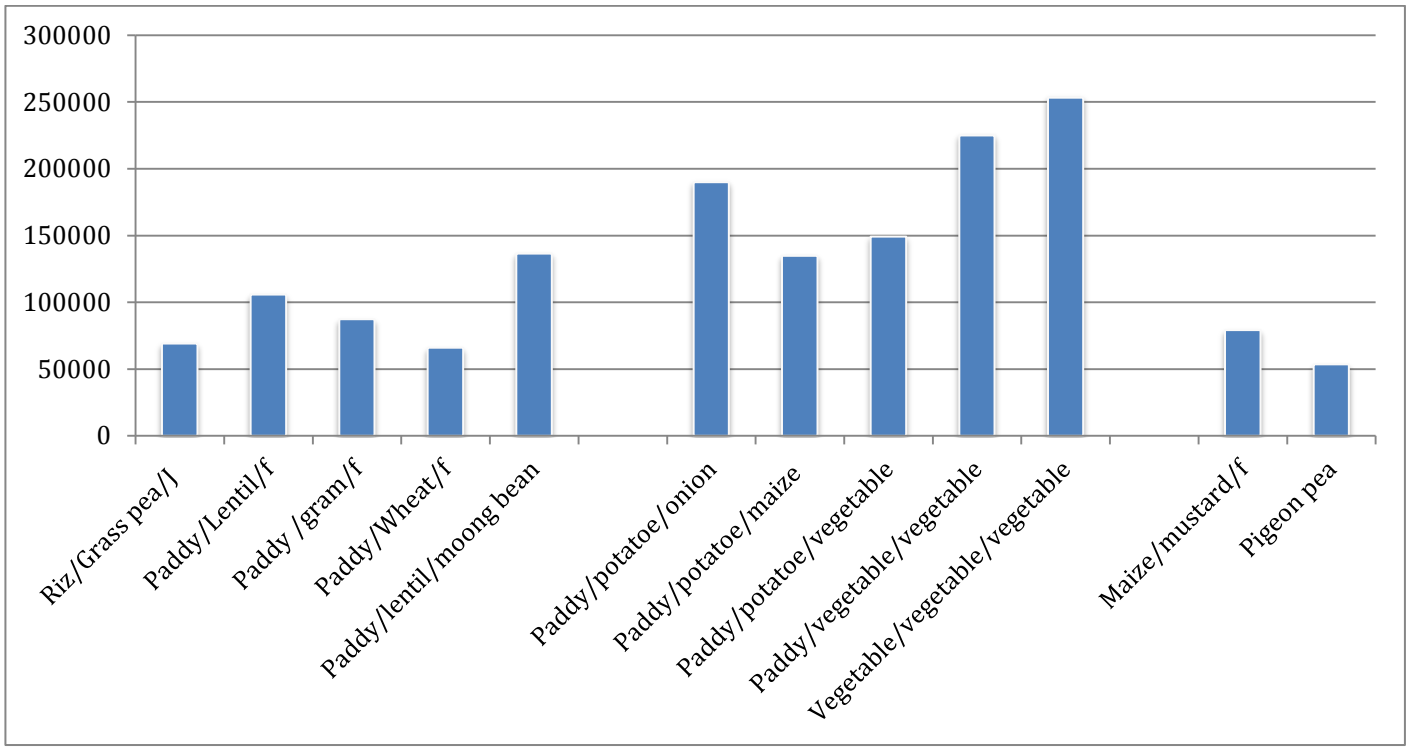
Several indicators can be used to compare cropping systems. In the following part, we choose to analyse the productivity of land (gross added value per hectare) and the labour productivity (gross added value per men-day) for all these systems.

The chart below (graph 9) shows teak tree has an important economic advantage per hectare. However, if farmers want to produce teak trees they have to wait 30 years. Moreover farmers need investments when they plant trees. Therefore, only rich people can invest in these plants. They do not plant an entire plot. They prefer to put some trees near their houses. Other farmers need regular income, that is why the prefer plant other crops. Last but not least, natural disasters have more chances to occur in 30 years than in one year.



Graph 9 : Productivity of land for cropping systems (GVA/hectare)

In order to see more precisely differences between the other systems, teak tree system is deleted (graph 10).



Graph 10 : Productivity of land for cropping systems, except teak tree (GVA/hectare)

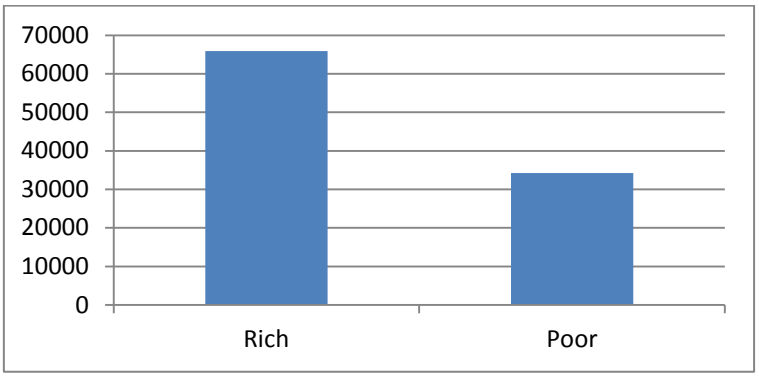
On the chart above, we note systems with vegetable production in board sense (vegetables, potatoes and onions) are the most profitable per hectare. Among all these systems, we can clarify that vegetables are more profitable than potatoes, because systems with two to three vegetable productions have a better productivity per hectare. All of these results show that vegetable represent an intensification of lands. Vegetables increase the gross added value. Vegetable production per hectare (yield) is higher than grain yield (4 times in average).

At the opposite, grain rotations get fewer benefits. We note that pulses are more interesting than wheat. Even if yield of lentils and gram are lower these two products are favourably priced. Nevertheless, in wet years, yield may be negligible. Therefore, farmers prefer to plant wheat.

It is interesting to note that if farmers plant 3 crops they have better economic results. However small farmers are not able to plant 3 crops, lack of water restrict them.

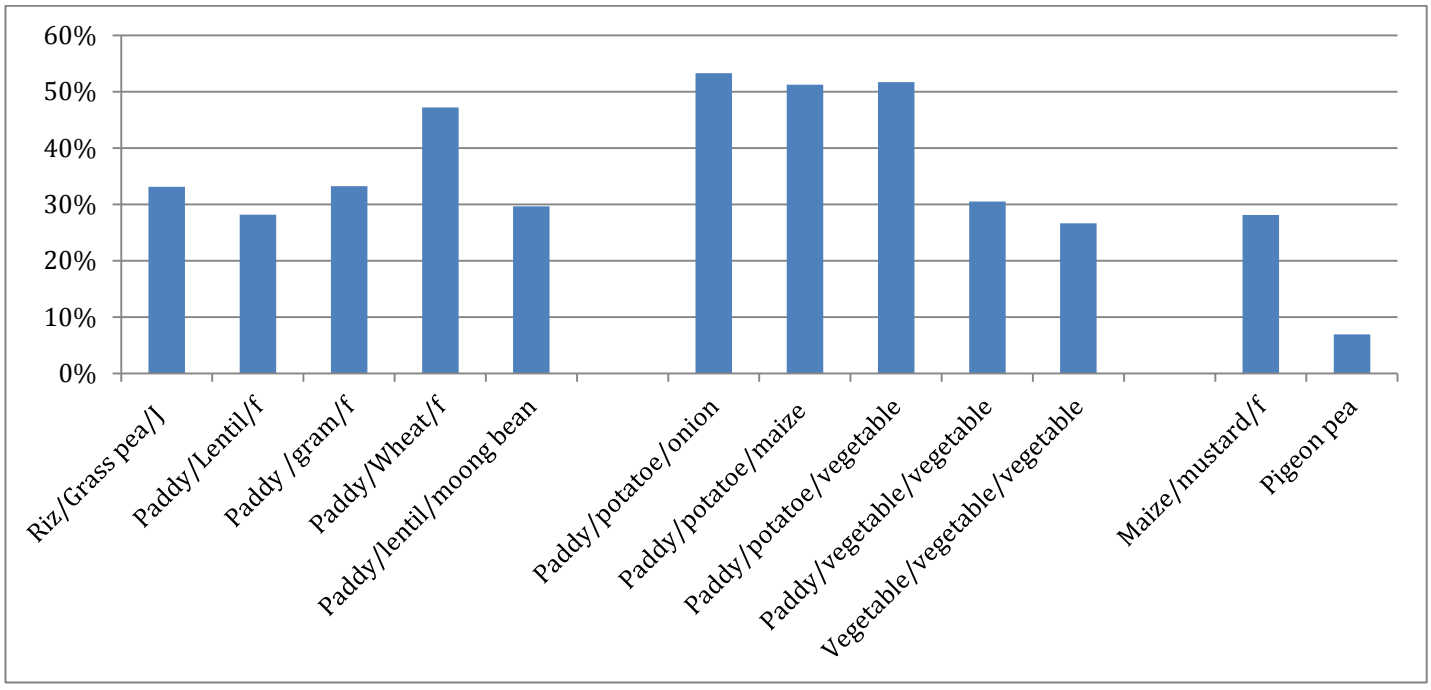
The last two systems (CS11 and CS12) are realised in high level lands. Even if they have poorer economic result farmers cannot grow other cropping system on these lands. Moreover these systems are done for self-consumption and diversify production.

In Ekangar Sarai block, yields are different between rich and poor. Rich people can use better seeds, apply more fertilisers, protect their crops and have regular access to water. Poor people have very poor yield and even if they use less input, economic results are bad, as shown in the following chart.



Graph 11 : difference of yield between rich and poor farmers for the rotation paddy/wheat/fallow

Another indicator can be used in order to highlight the productivity of all these systems. This indicator measures the share of intermediate consumption in gross product (graph 12). Thus, we note that intermediate consumptions of potatoes are higher than of vegetables, due to many inputs (fertilisation, pesticides, etc). This explains the more important profit of [vegetable/vegetable/vegetable] system. Onion crops require also lots of inputs. However, the sale price of onion is very high and offsets the high level of intermediate consumption. Thus, onion and vegetables crops are both profitable.



Graph 12 : Intermediate consumption/Gross product (%)

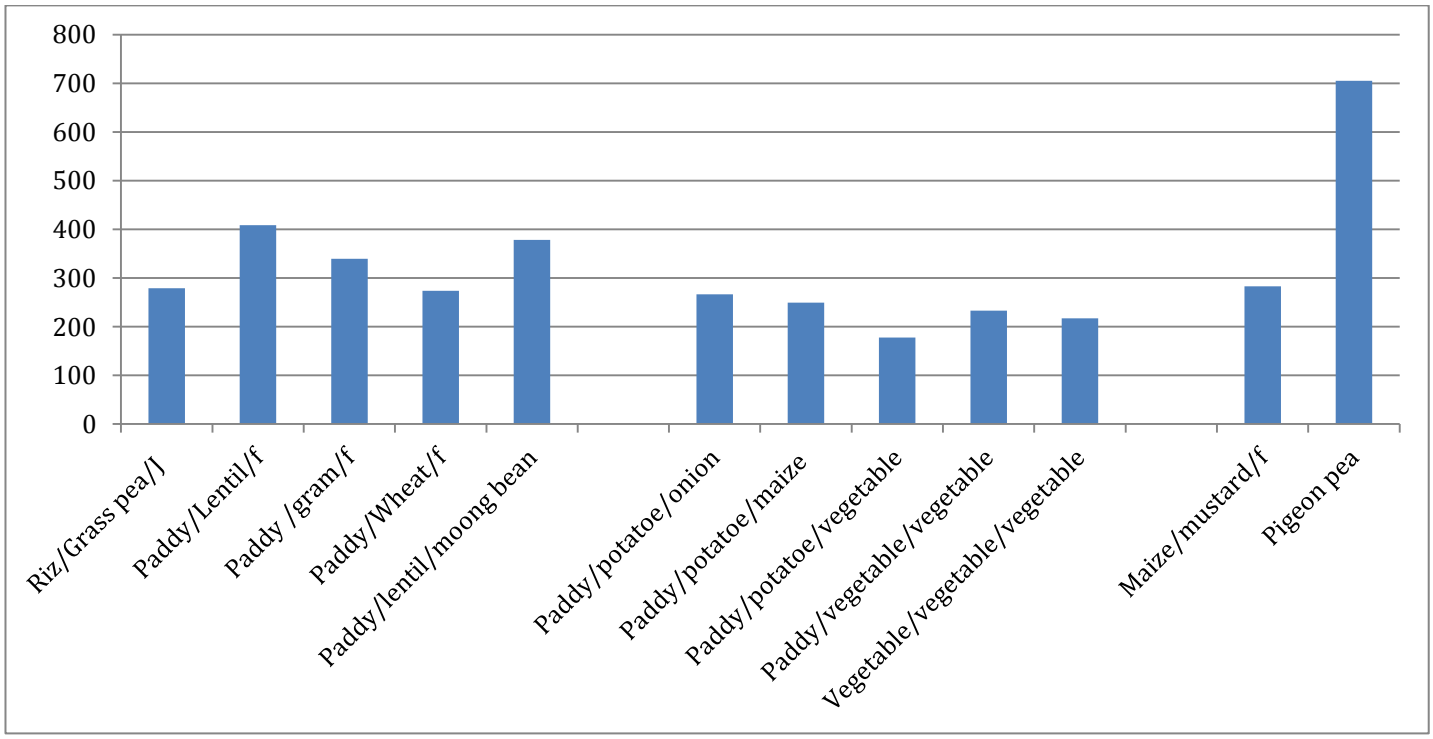
Overall, grain and legume systems are less profitable. The low productivity per hectare of [paddy/wheat/fallow] system is explained by its high intermediate consumptions. More precisely farmers put more inputs on wheat crops than legume crops.

Some systems highly depend on inputs like fertilizers and pesticides. In India, fertilizers are subsidised by government. If one day government stop to subsidise fertilizers rate will go up. Farmers must always remember this fact.

In opposition to the productivity of land, labour productivity (graph 13) is low for vegetable systems. Indeed, systems with vegetable, potato and onion production are labour-intensive. Thus, the biggest farmers, who hire labourers to cultivate their lands, prefer to grow grain or legume systems which require less labour.

Moreover, teak tree system, also grown by the biggest farmers, is not represented but its labour productivity is very high (25 000Rs/men-day).

Conversely, farmers who have small lands but lots of family workforce will choose to grow vegetables or onions in order to improve their gross added value. The cropping system 4 (paddy/wheat/fallow) becomes more interesting if we focus ourselves on this indicator. The same applies to cropping system 11(maize/mustard/fallow).



Graph 13 : Labour productivity of cropping systems, except teak tree (GAV/men-day)

5.3.Livestock rearing systems

Before to present each of them, here is a list of livestock rearing systems found in the Ekangar Sarai block:

- LS1: One buffalo grazing a part of the year, reared by workers and landless in villages.
- LS2: Three buffalos of middle dairy farm (PS5) grazing a part of the year.
- LS3: One buffalo in tie-stall (zero-grazing), reared by big grain farm (PS1).
- LS4: Two cross-breed cows (Sahiwal) in tie-stall, reared by middle farm (PS3 and PS4).
- LS5: Four cross-breed cows in tie-stall (zero-grazing), reared by middle dairy farm (PS5).
- LS6: Seven high genetic cross-breed cows, reared by big grain farm with dairy production (PS6).
- LS7: 3 goats grazing all year, reared by landless.
- LS8: 2 free hens, reared by scheduled cast.
- LS9: flock of sheep, reared by the Gaderia.
- LS10: fish farm, reared by big grain farm.

Another livestock rearing system is present, oxen. They are reared to plough fields. However just few farmers living in remote villages, keep these animals. As the result, we do not describe this system.

Each system is presented by a description and a scheme (see appendixes). One example is shown for the livestock rearing system 2[28].

5.3.1. The position of livestock in the block

5.3.1.1. The dairy production promoted by Sudha

Sudha cooperative was created in 1983. This cooperative started its actions in North of Bihar. In Ekangar Sarai block, the first collect centre in village has opened in 2003. Nowadays, there is one big centre in Ekangar Sarai which collects milk of 200 village collect centres based in four blocks. Farmers sell their milk without limitation. They do not have problem with price because they are fixed. Moreover Sudha offers concentrate feed and minerals to bargain price. And last but not least, Sudha helps farmers who want to buy a cow. They subsidise 50% of cow price.

All of these aspects have an impact on farmers' practices:

- Farmers rear more cow than 10 years before,
- Farmers feed their cattle with more concentrate feed,
- Farmers know that if they cannot sell their milk in village they can give milk to Sudha.

5.3.1.2. Upgrading beef meet

In the block, we noted the presence of beef sector. Indeed, some farmers sell their calves (cow or buffalo) and their cull buffalos to a butcher in the block or neighbouring blocks. They also sell them to middle men. These middle men are Hindu or Muslim. They go in villages to buy calves and cull animals. Then they sell them to Muslim. Animals are group in Uttar Pradesh. Next they are exported to others countries, notably in Southeast Asia. This beef sector allows valorising calves and cull animals. However, big farmers do not use directly this chain. First they sell their

[28] Appendix B

animals to scheduled castes. Theses castes rear animals during 1 or 2 years more and at the end sell them.

5.3.1.3. The other livestock systems

In the block other livestock exist. They are used for meat production. Excepted vegetarian, all Bihari castes eat chicken, goat (in the block mutton) and fish meats. Nevertheless only scheduled castes eat ducks and pigs.
Chicken are reared all year long, excepted during rainy season. In the block two types of chicken are reared: villagers chicken reared by scheduled castes or farm chicken reared in big poultry houses.
Fish are consumed only during summer season. Fries are put in pound after rainy season. They become mature in March. Goats are cooked all year round like chicken. We note that for Holi festival or other events rich farmers are used to buy a goat.

Generally eat meat is a sign of wealth but rear feeder animals is reserved for scheduled castes. Therefore, forward or backward castes use scheduled caste at that time.

5.3.2. Bovine systems

5.3.2.1. LS 1 | Buffalo grazing a part of the year

LS1

This rearing system has one buffalo which graze four to five hours, during summer season. The rest of the year, buffalos receive grass which is cut by women in fields or follow lands. Farmers do not give them other green feed. When farmers have enough money, they can purchase concentrate feed. In average they buy 3 bags of 50kg per year. This could be Sudha concentrate feed (composed of maize, soybean, etc) or wheat flour. Buffalos receive about 1 kg of concentrate feed, when they have bought bags. Farmers also give them wheat and paddy self-produced straw all year. Landless who have a buffalo have to purchase straw.

Buffalos need to take a bath in order to regulate body temperature. In summer season, farmers often wash them in a pond during grazing time. Children, old farmers and women take care of buffalo.

These buffalos produce 900L of milk per female per lactation. Farmers self-consume a large portion of this milk (61%). They sell their surpluses to the collect centre in their village. Dung has an important place in this system (19% of gross product). Indeed, all the dung is kept in order to be used as fuel for cooking. Farmers use to sell calves. They kept only some females in order to replace their old buffalos, which die on the farm.

As with all the livestock rearing systems, reproduction is ensured by artificial insemination. For ten years, buffalos have inseminated at a cost of 150Rs/injection. The calving interval is 18months[29].

Some buffalo reared by landless graze all the year. Children, old people or women look after animal during the time that animals graze.

[29] Appendix D

Figure 54 : Buffalos grazing during summer season

5.3.2.2. LS 2 | Buffalos in middle dairy farm, grazing a part of the year LS2

Farmers who have this system keep on average 3 buffalos. These farmers often belong to Yadav caste. They want to earn money thanks to their herd. Thus, they sell about 60% of the produced milk to a Sudha collect centre. One buffalo produce in average 1300L per lactation. Animals are milked until two month before giving birth. The calving interval is 18 months. As regards the others livestock products, dung are used for cooking (6% of gross product) and as manure (3% of gross product). Like the previous system, calves are sold. Old buffalos died on the exploitation. Mortality rate is around 33%.

Buffalos are pastured during summer season. Fodders (clover) are cultivated during winter season in order to feed them. In rainy season farmers cut the weeds in their plots to feed cattle. They receive also straw produced on the farm. Concentrate feeds are bought by farmers. They give 1,5kg to their females. Mustard press cakes are given according availability.

2

Buffalos in middle dairy farm

3 she-buffaloes

333 man-days

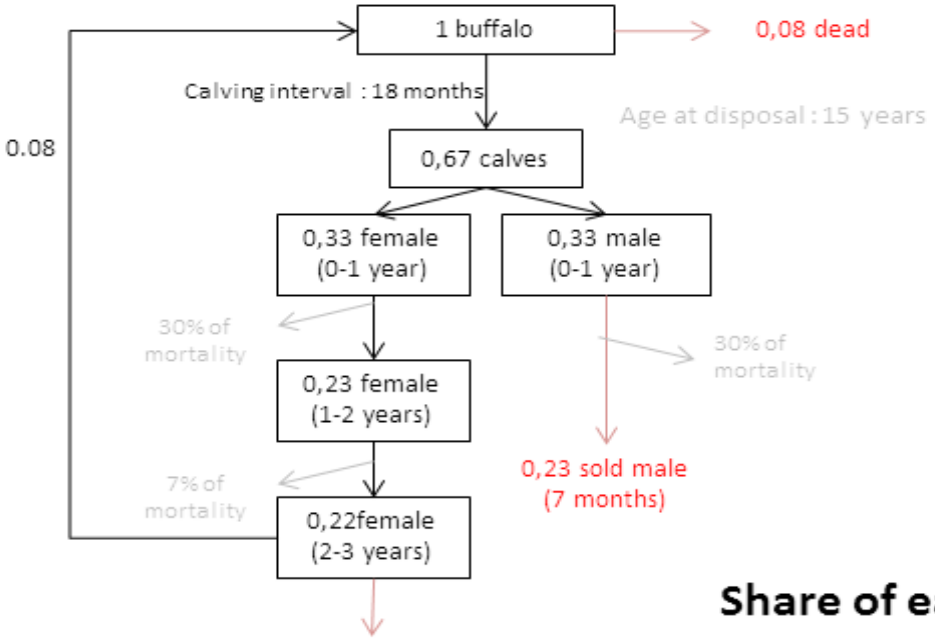
1 buffalo

Intermediate consumption

Feeding

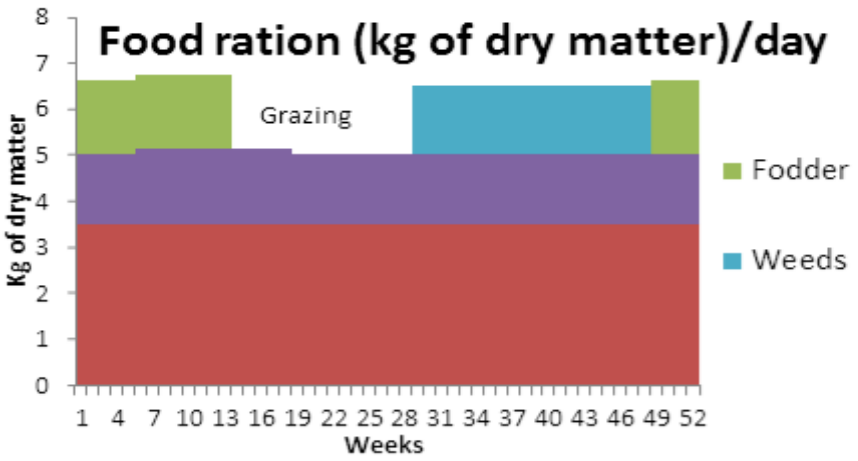
- **Straw**
  2t — 3 200Rs
- **Concentrates**
  0,9t — 15 700 Rs
- **Green fodder**
  14t — 100Rs
- **Grazing**

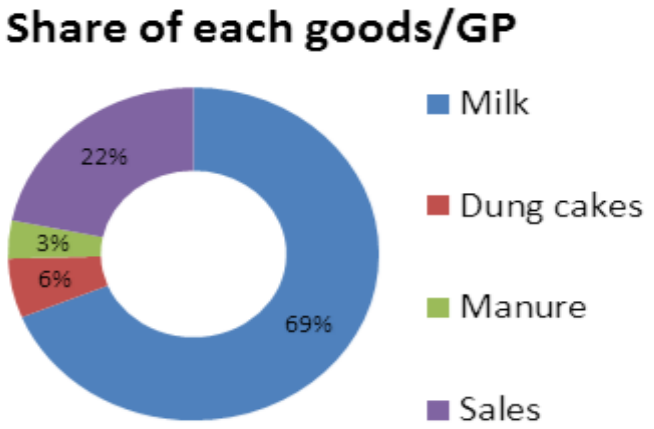
Reproduction & care — 550 Rs



Products

Milk : 900L	26 200 Rs
Manure and dunk cakes: 5t	3 500 Rs
Calves (0.37)	7 900 Rs





GP : 37 600 Rs IC : 19 550 Rs GAV : 18 050 Rs

GP : 112 700 Rs IC : 62 550 Rs GAV : 50 150 Rs

5.3.2.3. LS 3 | Buffalo in tie-stall (zero-grazing)

LS3

The biggest farmers who are not specialised in dairy production choose to keep a buffalo. Indeed, they prefer the taste of buffalo milk rather than that of cow milk. Their buffalo stay continuously tethered. They are entered in the house morning and evening. A labourer can be hired in order to look after the animal.

The buffalo is fed with green fodder, straw and concentrate feed all year. Concentrate feeds are largely self-produced. This could be mostly wheat and maize flour. Press cakes of mustard are also given. Fodder and straw are cut and mixed together, with water.

Like the other systems, all buffalos are inseminated. However there are lots of problem to inseminate this animals. Indeed animals do not take bath, so they fertility decrease.

A buffalo gives 1 600L of milk per lactation. It is entirely self-consumed, and all the dung is used for cooking. Male calves could be sold at the age of 2 years to meat sector. Generally a part of female calves are kept in order to replace the old female buffalos. These old buffalos could be sold to small farmers[30].

Figure 55 : Buffalos in tie-stall

5.3.2.4. LS 4 | Cross-breed cows in tie-stall (zero-grazing)

LS4

This system has two cross-breed cows. These cows are crossbred of local breeds and cows with better milk production potential. One of the breed that could be identified is Sahiwal.

Cows receive green cultivated fodder a part of the year (9 months). When they are not fed with cultivated fodder, farmers give them more concentrate feeds. Concentrate feeds are wheat and

[30] Appendix D

maize flour, industrial concentrate feeds produced by Sudha, or press cakes of mustard. Farmers produce themselves a part of concentrate feeds (press cakes and flour).

A cow produces about 1 500L of milk per lactation. Half of this milk produced is self-consumed. Surpluses are sold in collect centres. A part of the dung is dried to be used as fuel, and another part, used as manure, is applied on fields.

Like the previous system, some female calves are kept to replace the older cows, the others calves could be sold. Old cows are also sold to small farmers. Cows are milked 12 months in average. Calves mortality rate is 18%[31].

5.3.2.5. LS 5 | Cross-breed in tie-stall, in middle dairy farm (zero-grazing) LS5

Middle dairy farms have 4 cross-breed cows. Like the previous system, these cows are fed with cultivated fodder, during a part of the year only. The rest of the year, the lowest amount of fodder is offset by a larger amount of concentrate feeds. Straw and a part of press cakes and flour are produced on the farm. Minerals by in market are added to the ration.

About 84% of the 2 200L of milk produced per female and per lactation is sold to collect centre. Manure is kept and applied on plots in order to fertilise them. A small part of dung is used as fuel[32].

5.3.2.6. LS 6 | High genetic potential cross-breed in big grain farm with dairy production LS6

Herds of these farms are composed of seven to eight cows which are crossbred of Indian breeds with Friesian or Holstein cows, with a high genetic value. This type of rearing is relatively new. Farmers have increased the number of their cows progressively. They have had seven to eight cows for 3 to 5 years only. They hire one labourer in order to look after the herd.

These cows receive straw, cultivated fodder and concentrate feeds all year. The composition of feed ration is constant over the lactation cycle. Straws and fodder are produced on the farm. Press cakes, flour and other concentrates such as maize grain are partly self-produced. However, farmers have to purchase other concentrate feeds (Sudha concentrate feeds, flour, etc) and minerals to supplement the ration.

The productivity of this system is 3 350L per female and per year. Farmers sell 94% of produced milk to Sudha collect centres or to villagers. More than 85% of dung is applied on fields as manure.

Mortality of calves is more important in this system (more than 50%). This phenomenon concerns more male calves. Some farmers have said that all their male calves died. Male are embarrassing so farmers do not take care about them[33].

[31] Appendix D
[32] Appendix D
[33] Appendix D

Figure 56 : Highly productive cross breed cows

Use of cow and buffalo dung

Animal dung can be used as fuel or manure, which is applied in fields.

1. Cow and buffalo dung are mixed with crop residues and dried on the walls of houses, in order to use them for cooking. These dung cakes is replaced by crop residues (mustard, pigeon pea, etc) during winter season in order to keep dung for the rainy season.

2. Farmers, who have more than one cow, have enough dung for cooking. Thus, they use surplus of dung in order to fertilise their plots. Most of the time, manure is applied on fields in May. One plot receives organic fertilisation about every three years. The year in which manure is applied on one plot, the quantity of chemical fertilisers for paddy crop is divided by half.

5.3.3. Other systems

5.3.3.1. LS 7 | Goats grazing all year round

LS7

Landless farmers, who do not have enough money to buy a buffalo or a cow, have a little herd of goats. Generally, a herd is composed of three female goats. They graze all year round. Most of time, goats are property of women. If a member is available (generally children or older people), he can keep the goats. Otherwise, goats are tethered while owners work as daily labourers. In addition to grass, goats are fed with straw and concentrate feeds (flour or pulses) after calving, during one to two months.

Farmers have goats only for meat production, milk is not consumed. Kid goats are sold at the age of three to four months. The sales seem to be more important for the Hindu festival of Holi. Reproduction is ensured thanks to billy-goats without owners which are in villages. All people take care about him[34].

5.3.3.2. LS 8 | Free-range hens

LS8

In order to complete their income and to eat some meat and eggs, the poorest farmers keep about two hens. They are free-range and eat leftover feed. Mortality rate is high. However some farmers try to protect chicks when they are young. In average, one hen does 3 litters of 5 chicks per year[35].

5.3.3.3. LS 9 | Sheep herd

LS9

For generations, shepherds are present in the Ekangar Sarai block. They belong to the *Garderia* caste. They keep some sixty sheep, of which about thirty-five ewes. They bring their herd to graze during 8 to 10 hours per day. The night, they can sleep with their sheep on plots in order to fertilise them. The owners of fields have to pay for this service. Sheep are reared to produce meat, and lambs are sold in local market. Births are synchronized in October and November. Calving rate is relatively low because of abortion problems. With the wool, shepherds' wives make blankets, which they sell in the village. Shepherds can milk some of their ewes in order to self-consume it or to make ghee (clarified butter).

This system tends to dwindle in the coming years. Indeed, more and more shepherds sell their animals[36].

[34] Appendix D
[35] Appendix D
[36] Appendix D

Figure 57 : A shepherd with his herd

5.3.3.4. LS 10 | Fish farm

LS10

The biggest farmers, who are not specialised in dairy production, choose to develop a new activity: the fish farming. They have dug some plots to create ponds in order to rear fishes. Fishes are breed during four months, and then they are sold in local markets. Generally, owners hired labourers to feed them, third a week.

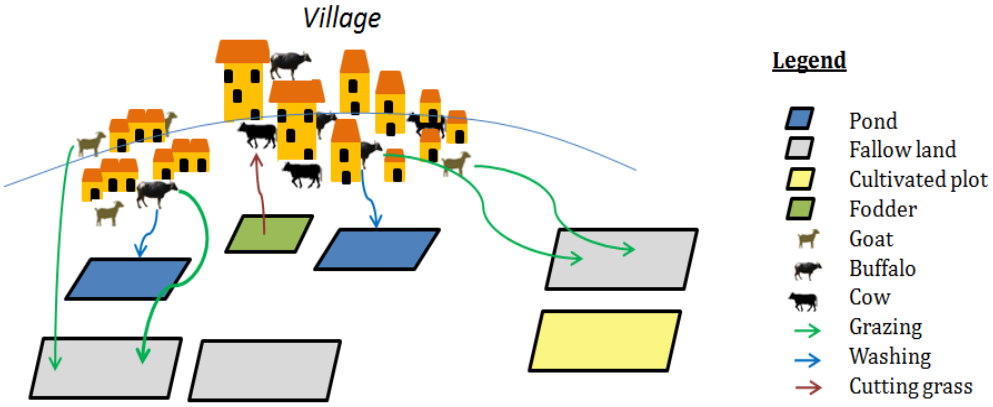
This system is expanding for this type of famers. Fishes breed are. Fry come from west Bengal. Fry are put in pound after rainy season. They are sold during summer season[37].

Figure 58 : Fishing

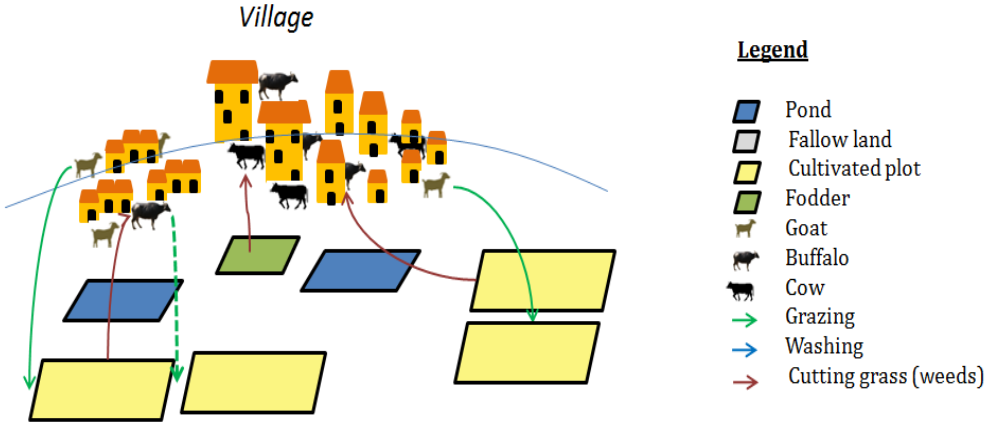
[37] Appendix D

Grazing in the study area

As we have seen above, several kinds of animals graze on fields. Grazing activities change during the year. Indeed, during summer season, lots of plots are fallow and allow buffalos and goats to pasture. Cows and buffalos in tie-stall are still fed with fodder. Due to the higher temperatures in summer season, buffalos have to take a bath more frequently.



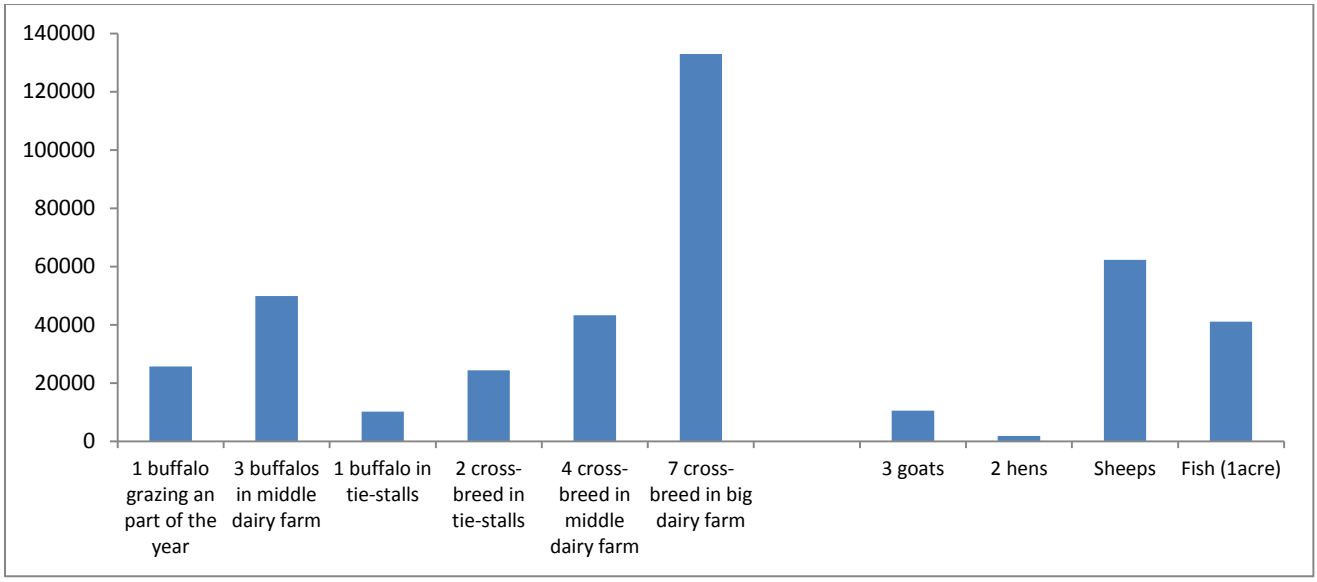
During rainy and winter season, plots are planted with paddy and wheat, which of residues will be used to feed bovines and goats. Some farmers graze their animals during all year. Thus, when plots are cultivated, buffalos and goats graze on the side of roads and plots. Some farmers harvest weeds to feed their cattle.



5.3.4. Comparative analysis of livestock rearing systems

5.3.4.1. Global analysis

After the description of each livestock rearing systems we are going to compare them.



Graph 14 : Gross added value of livestock rearing systems per year

This graph (graph 14) allows us to compare the gross added value of each livestock rearing system.

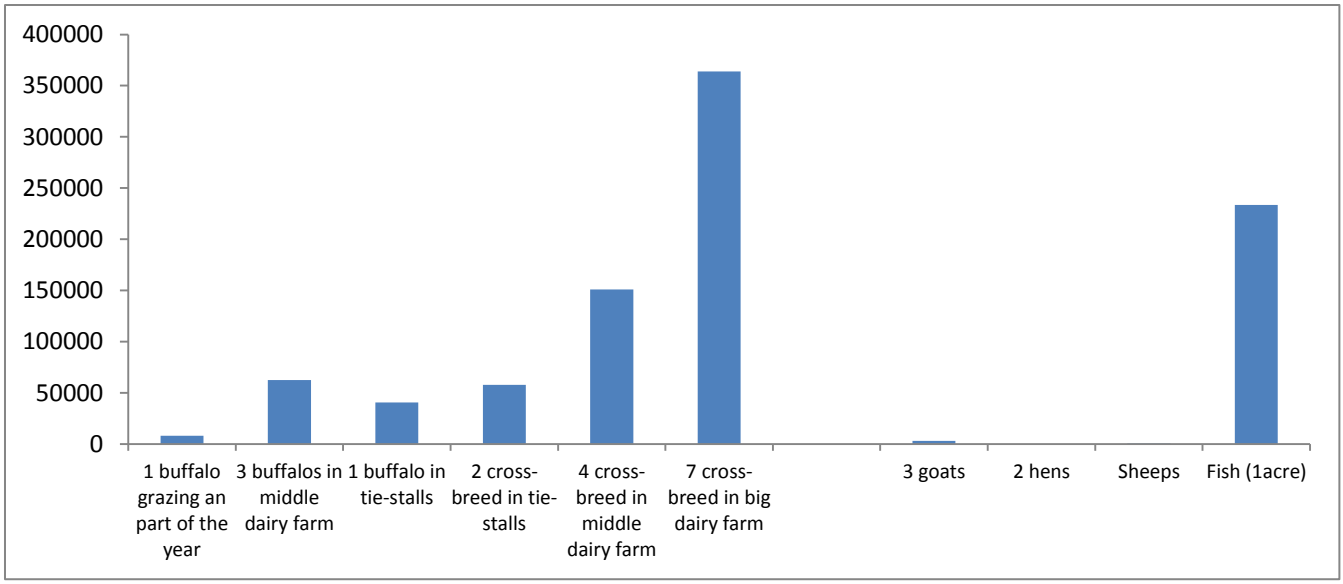
We can note the impact of investments in dairy production. Indeed livestock rearing system 6 (7 cross-breed cows) has the best results. High genetic cows produce more milk and results seem better. Nevertheless owners do not work on their farms. They have to pay a salary to their permanent workers. Therefore, results have to be considered in context.

We note that grazing systems (LS1, LS2 and LS9) have good result. Even if their production is not high, farmers limit the number of inputs. In that case it is interesting to preserve animal with low production. These animals have less needs, and they can support a ration composed of weeds and straws. At the opposite even if livestock rearing system 6 has good result, it is highly dependent on inputs like concentrate feeds. Therefore, if concentrate feeds rate vary, product will be affected.

Livestock rearing system 3 (1 she-buffalo in tie-stalls), seems uninteresting. These results should be put in perspective. Farmers do not look for dairy production. They have she-buffalo only for self-consumption. They produce all their feeds and do not limit the amount given. Their she-buffalos are in good shape.

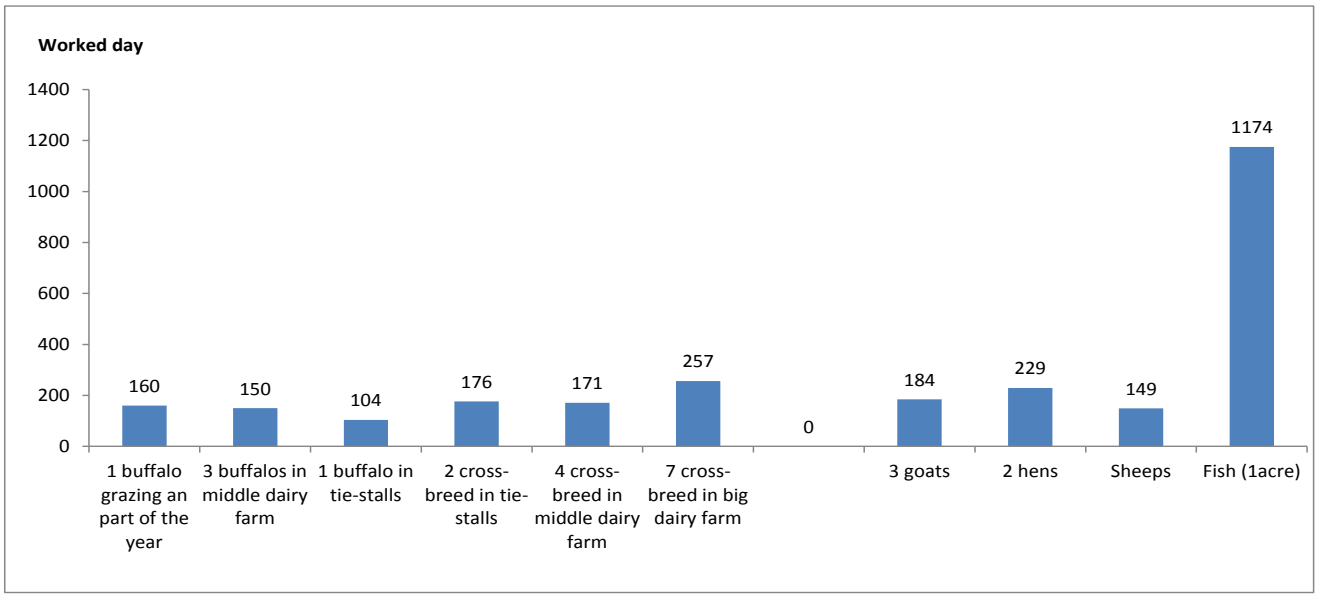
Results of livestock system 7 (3 goats) explain why it is difficult to these farmers to set some money aside in order to buy a she-buffalo or a cow. These goats are additional income for these farmers.

Below (graph 15), lector can find the table of intermediate consumption for each livestock system.



Graph 15 : intermediate consumption per year per livestock rearing system

The graph below (graph 16) shows the benefit per worked day.



Graph 16 : gross added value per worked day (GAV/men-day)

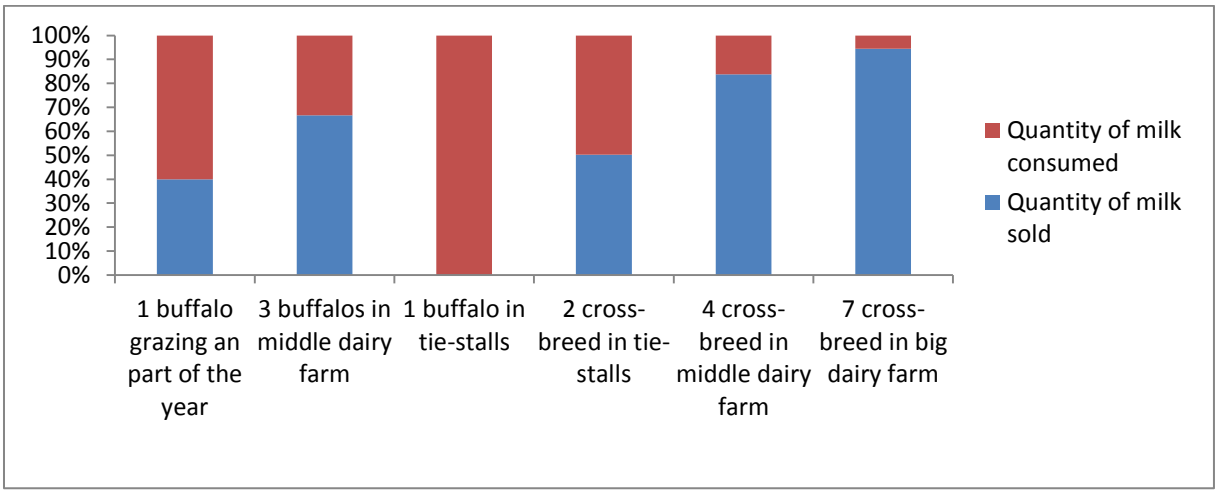
Fish farming looks like very interesting. In comparison with the other livestock rearing systems, fish farming needs less work. Farmers have just to give 3 times per week some feed. This applies to livestock system 7 (2 hens). Farmers let hens in the village. They just check the morning if hens and chicks are always here.

However, livestock system 6 raises a question (7 cross-breeds). Owners do not work on the farm. They earn 257Rs per worked day with this system and they say that they pay workers 200Rs per day. Their system is not perennial. We have done the hypothesis that salaries are lower that they said.

Other systems are around 150-175 rupees per day. This price is equivalent to a daily salary.

5.3.4.2. *Analysis of bovine systems*

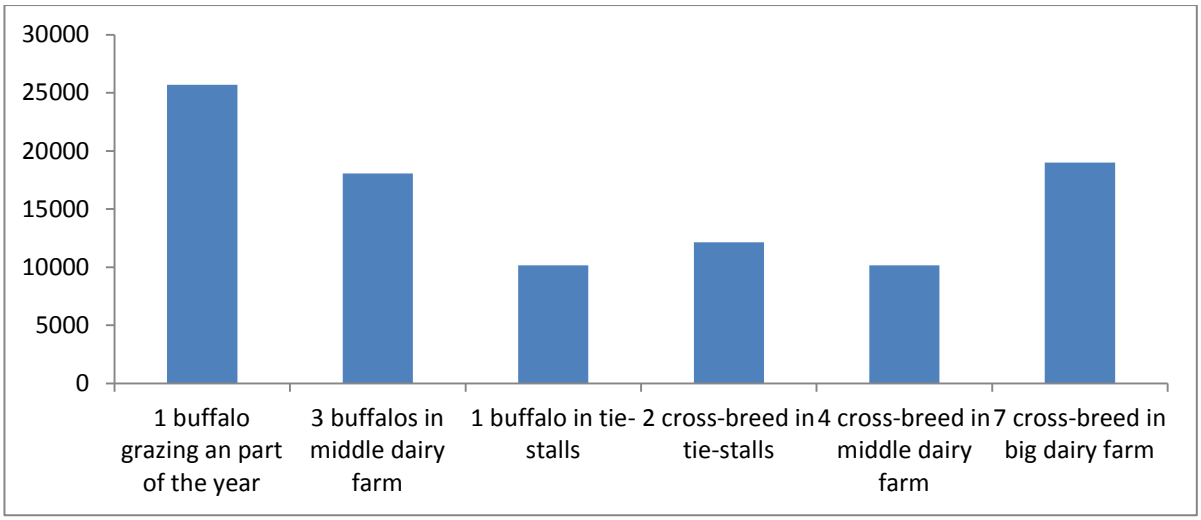
Each bovine system differentiates itself by the share of self-consumption (graph 17).



Graph 17 : share of milk self-consumed

As we have seen before livestock rearing system 3 (1 buffalo in tie-stalls) consumes all the milk produces. The second and the two last systems (LS5, LS6) are focus on milk production. At the opposite, other systems have bovines first for self-consumption. They only sell surpluses.

In order to focus more specifically on bovine livestock systems we are going to compare each system reduced to one cow (graph 18).



Graph 18 : gross added value per year and per animal

We have seen in first part of this analysis that livestock system 6 was more interesting. However if we compare the result per bovine the results appear more uneven. Grazing systems use less input and use “free” grass. However they are dependent on the landscape evolution. There are less grazing systems than 30 years ago. Intensification of crop production reduces fallow lands. Nowadays grazing areas are limited to road side and canals during two thirds of the year.

If we compare livestock system 5 and livestock system 6 whose purpose is milk production, the difference depends on genetic. Livestock system 6 uses high genetic cows which produce more milk. Moreover, livestock system 5 is less autonomous, and has to purchase more feed.

In all these analyses, one must keep in mind the place of dejection. They are important for cook. Some farmers do not want to sell their cattle even if milk is not produced. According to them dung cakes are really important even if results do not show that.

6. Economic analyses of production systems

6.1.Analysis by production system

Production systems have been described previously. Now, the aim is to compare technical and economic performances of each type of farm, and to explain current dynamics. Thus, farm models are built, using cropping and livestock rearing systems. These models are a simplified representation of reality. The table below (table 1) reminds the different types of farm and their activities.

Table 5 : Reminder of the production systems

Number	Type	Characteristics	Valorisation
PS 1	Big farm	Grain production and fish farming	Permanent and daily labourers
PS 2		Grain and dairy production	Permanent and daily labourers
PS 3	Middle farm	Grain production	Daily labourers
PS 4		Grain and Vegetable production	Daily labourers
PS 5		Dairy production	Daily labourers
PS 6	Small farm	Vegetable production	Daily labourers
PS 7		Grain production	Daily labourers
PS 8		Grain production	-
PS 9a	Labourers	With buffalo	-
PS 9b		With goats	-
PS 9c		Permanent labourer	-
PS 10	Shepherd	Meat production	-

Absent owners are not represented below because they do not have farm. However, their rental incomes can be estimated. They rent their lands in *chaurha*, thus they earn 380kg of paddy per bigha (0,25ha), 25 840Rs/ha.

All the others model farms are presented by schemas below.

PS1

BIG GRAIN FARM WITH FISH PRODUCTION 2,5-15ha

In blue example of farm
UAL : 7,6ha

Family worker : 2
Family : 6 members

These farms are specialized in grain crops. They have some difficulties to find laborers that is why they produce grain crops. They have lots of equipment. Owners are powerful and take part in meeting. These farms hire minimum one permanent worker. Daily workers are hired according to needs. The buffalo produces dairy products for self-consumption. The owner looks after the work and drives the tractor.

Inputs (farm 7.6ha)

Seeds	86 200 Rs
Fertilizers	93 800 Rs
Pesticides	50 500 Rs
Feed	201 800 Rs
Reproduction & care	550 Rs
Fish fry	14 000 Rs
Electricity	7 200 Rs
Fuel	53 000 Rs
Transformation and storage costs	1 700 Rs

- **CS4** RICE/WHEAT/Ø | 4,6ha
- **CS3** RICE/LENTILS/Ø or RICE/GRAM/Ø | 2ha
- **CS13** MAIZE/MUSTARD/Ø | 0,5ha
- **CS5** RICE/LENTILS/*MOONG* | 0.25ha
- **CS14** *RAAL* | 0.06ha
- **CS11** RICE/VEGETABLES/VEGETABLES | 0.05ha
- **CS6** RICE/BARSEEM/Ø | 0,03ha
- **CS7** MILLET/POTATOES/MILLET | 0,03ha
- **CS15** TECK TREE | 0,01ha
- **CS16** MANGO TREE | 0,01ha

Fodder 7t
Straw 4t

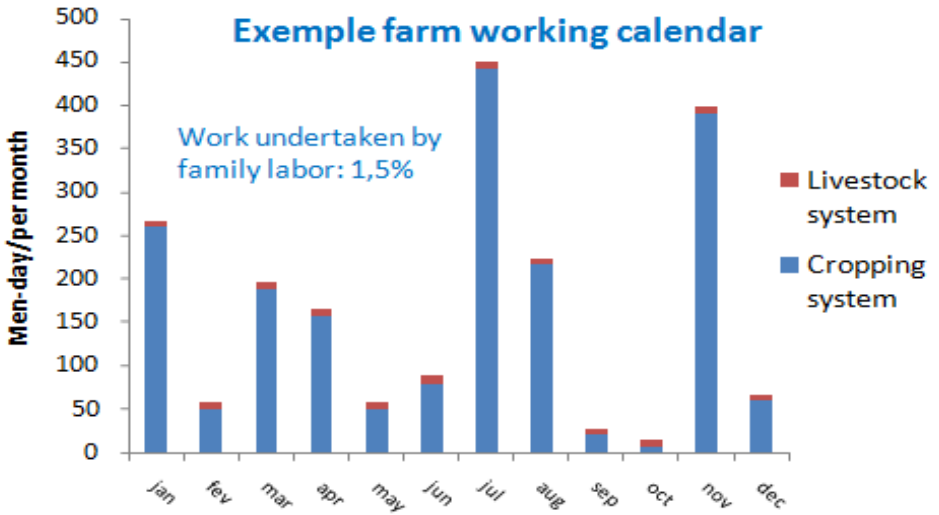
- **LS3** SHE-BUFFALOE IN TIE-STALL | 1 she-buffalo
- **LS10** FISH FARMING | 0,4ha

Outputs (farm 7,6ha)

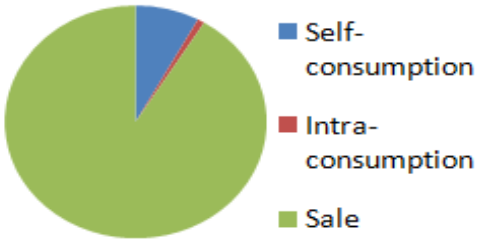
Wheat	213 800 Rs
Rice	514 900 Rs
Pulse	130400 Rs
Maize	35 400 Rs
Vegetables	28 300 Rs
Oilseeds	19 200 Rs
Moong bean	12 000 Rs
Teck tree	5 000 Rs
Mango	12 000 Rs
Crop residues	87 000 Rs
Milk (1000L)	34 900 Rs
Dunk cakes (6T)	6 800 Rs
Calves selling	8 900 Rs
Fishes	274 500 Rs

Equipment:
Tractor
Plow
Thresher
3 pumps
Seeder
Rigid pipes
Other equipment

Exemple farm working calendar



GP repartition (example farm)



GP	1 389 900 Rs
IC	508 750 Rs
GAV	881 150 Rs
Depreciation	72 900 Rs
NAV	808 250 Rs
Laborers salary	321 600 Rs
Taxes	1 100 Rs
Interests	3 000 Rs
Agricultural Income	**480 600Rs**

PS2 BIG GRAIN FARM WITH DAIRY PRODUCTION 2-10ha

Family worker : 2
Family : 6 members

In blue example of farm
UAL : 6,5ha

These farms look like the previous production system. However, they have developed their dairy sector in order to have more benefits. In future they would like to developed their own production. They have also lots of equipment. The owners are powerful and take part in meeting. One permanent worker takes care of animals. The others activities are realized by daily workers.

Inputs (farm 6.5ha)

Seeds	68 700 Rs
Fertilizers	77 500 Rs
Pesticides	42 300 Rs
Feed	327 500 Rs
Reproduction & care	5000 Rs
Electricity	7200 Rs
Fuel	45 900 Rs
Transformation and storage costs	1700 Rs

CS4 RICE/WHEAT/Ø | 4,1ha
CS3 RICE/LENTILS/Ø or RICE/GRAM/Ø | 1.25ha
CS13 MAIZE/MUSTARD/Ø | 0,63ha
CS14 *RAAL* | 0.06ha
CS11 RICE/VEGETABLES/VEGETABLES | 0.04ha
CS6 RICE/BARSEEM/Ø | 0,04ha
CS7 MILLET/POTATOES/MILLET | 0,04ha

Manure 32t ↑ ↓ Fodder Straw

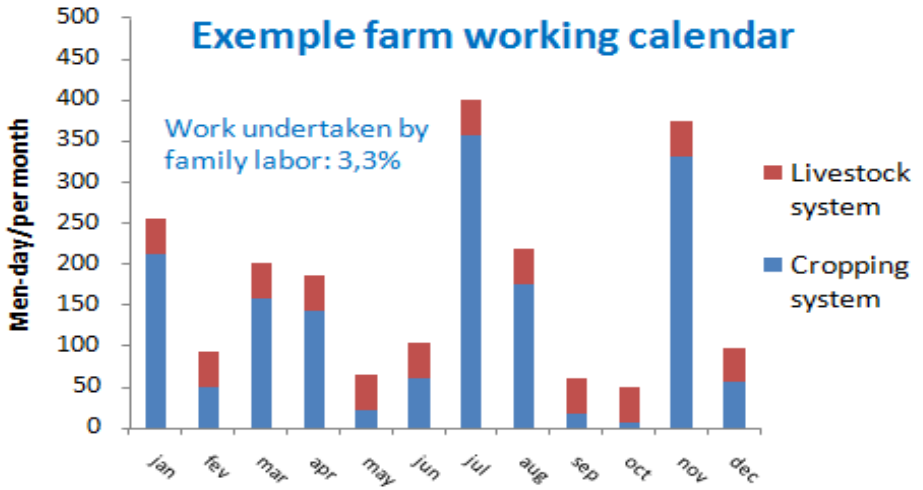
LS6 CROSS-BREED IN BIG DAIRY FARM | 3 cows

Equipment:
Tractor
Plow
Thresher
3 pumps
Rigid pipes
Other equipment

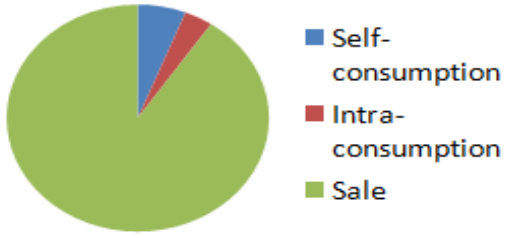
Outputs (farm 6,5ha)

Rice	413 800 Rs
Wheat	197 800 Rs
Pulses	73 600 Rs
Oilseed	23 700 Rs
Maize	45 700 Rs
Potatoes	6 900 Rs
Vegetables	10 800 Rs
Crop residues	51 400 Rs
Milk	423 400 Rs
Animal selling	53 400 Rs
Dunk cake	6 900 Rs

Exemple farm working calendar



GP repartition (example farm)



GP	1 349 800 Rs
IC	620 300 Rs
GAV	729 500 Rs
Depreciation	72 000 Rs
NAV	657 500 Rs
Laborers salary	310 000 Rs
Taxes	900 Rs
Interests	4 800 Rs
Agricultural Income	**341 800Rs**

PS3

MIDDLE GRAIN FARM
1-3ha

In blue example of farm
UAL : 2ha

Family worker : 2
Family : 6 members

Differences between these farms and the first production systems, are the equipment . These farms have less financial resources. They hire only daily workers. They can sell milk surpluses of their 2 cows. The owner looks after the work.

Inputs (farm 2ha)

Seeds	26600 Rs
Fertilizers	26 200 Rs
Pesticides	13 200 Rs
Irrigation	24 000 Rs
Feed	46 800 Rs
Reproduction and care	1 400 Rs
Fuel	19 500 Rs
Transformation and storage costs	1 900 Rs

CS4 RICE/WHEAT/Ø | 1,03ha
CS3 RICE/LENTILS/Ø or RICE/GRAM/Ø | 0,38ha
CS2 RICE / KESHARI / Ø | 0,25ha
CS13 MAIZE/MUSTARD/Ø | 0,5ha
CS5 RICE/LENTILS/*MOONG* | 0.06ha

CS10 RICE / POTATOES / VEGETABLES | 0,07ha
CS6 RICE/BARSEEM/Ø | 0,04ha
CS7 MILLET/POTATOES/MILLET | 0,04ha
CS14 *RAAL* | 0.04ha

Manure 5,5t ↑ ↓ Fodder Straw

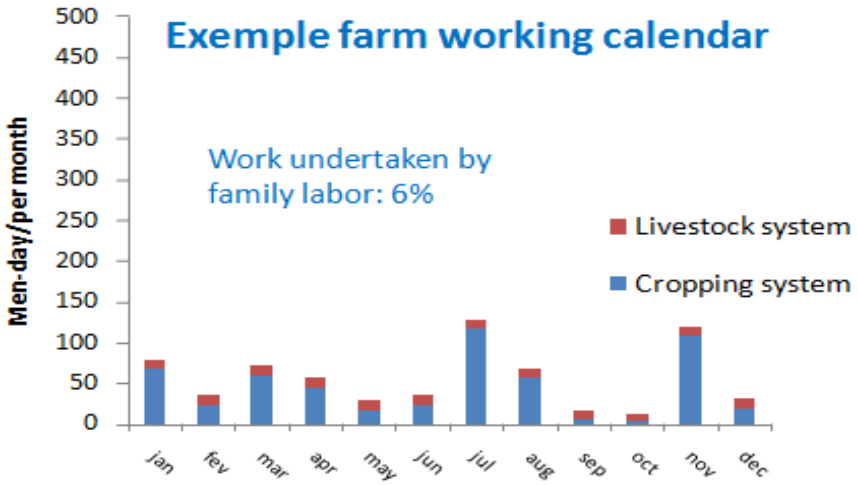
LS4 CROSS–BREED IN TIE-STALL | 2 cross-breed

Equipment:
Thresher
2 pumps
Other equipment

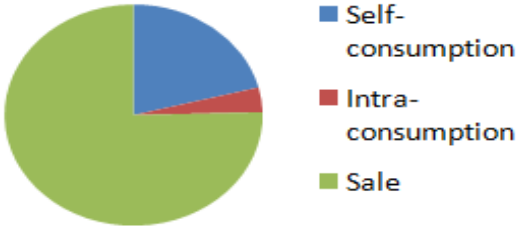
Outputs (farm 2ha)

Rice	137 000 Rs
Wheat	50 300 Rs
Pulses	30 500 Rs
Moong bean	3 200 Rs
Raal	1 200 Rs
Oilseed	6 100 Rs
Maize	9 300 Rs
Potatoes	13 600 Rs
Vegetables	11 100 Rs
Crop residues	15 300 Rs
Milk	58 200 Rs
Animal selling	18 900 Rs
Dung cakes	6 800 Rs

Exemple farm working calendar



GP repartition (example farm)



GP	369 300 Rs
IC	171 000 Rs
GAV	198 300 Rs
Depreciation	6 700 Rs
NAV	191 700 Rs
Laborers salary	103 000Rs
Taxes	300Rs
Interests	700 Rs
Agricultural Income	**87 600Rs**

PS4

MIDDLE VEGETABLE FARM 1-2ha

In blue example of farm
UAL : 1,75ha

Family worker : 2
Family : 6 members

These farms are located in the zone 1 and the owner belongs to the Mahto caste. He produces vegetables in order to improve his growth product and his financial resources. The owner hires some laborers in order to help him in his work. They can sell milk surpluses of their 2 cows. The owner looks after the work.

Inputs (farm 1,75ha)

Seeds	40 100 Rs
Fertilizers	32 700 Rs
Pesticides	14 400 Rs
Irrigation	27 500 Rs
Feed	46 800 Rs
Reproduction and care	1 400 Rs
Fuel	17 700 Rs
Transformation and storage costs	1 600 Rs

CS4 RICE/WHEAT/Ø | 0,75ha
CS3 RICE/LENTILS/Ø or RICE/GRAM/Ø | 0,5ha
CS10 RICE / POTATOES / VEGETABLES | 0,15ha
CS12 VEGETABLES/VEGETABLES/VEGETABLES | 0,13ha
CS8 RICE/POTATOES / ONIONS | 0,1ha
CS13 MAIZE/MUSTARD/Ø | 0,05ha
CS6 RICE/BARSEEM/Ø | 0,04ha
CS9 RICE/POTATOES/MAIZE | 0,04ha

Manure 5,5t ↑ ↓ Fodder Straw

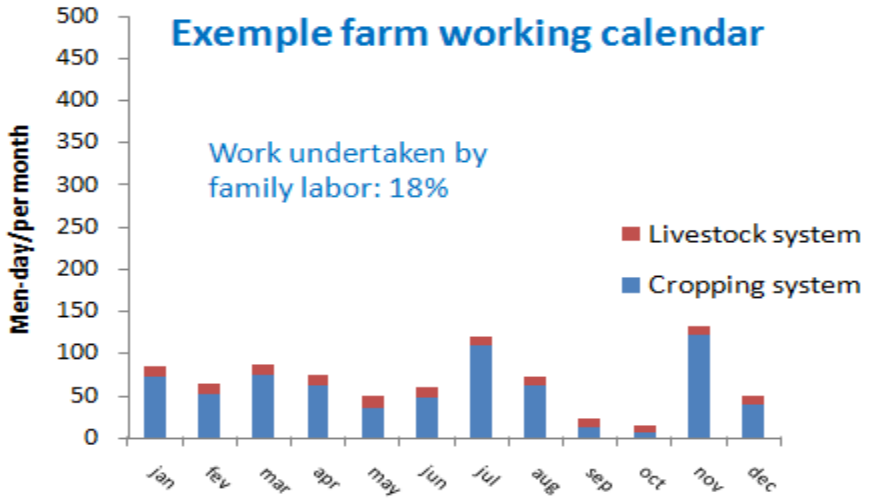
LS4 CROSS–BREED IN TIE-STALL | 2 cross-breed

Equipment:
Thresher
2 pumps
Other equipment

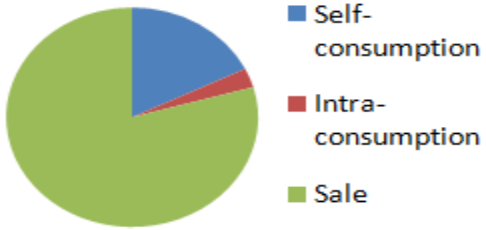
Outputs (farm 1,75ha)

Rice	117 300 Rs
Wheat	37 400 Rs
Pulses	26 900 Rs
Oilseeds	2 400 Rs
Maize	6 600 Rs
Onions	25 100 Rs
Potatoes	40 600 Rs
Vegetables	61 400 Rs
Crop residues	10 500 Rs
Milk	54 200 Rs
Animal selling	18 900 Rs
Dung cakes	6 800 Rs

Exemple farm working calendar



GP repartition (example farm)



GP	417 400 Rs
IC	191 200 Rs
GAV	226 200 Rs
Depreciation	5 200 Rs
NAV	221 000 Rs
Laborers salary	111 400Rs
Taxes	300Rs
Interests	600 Rs
Agricultural Income	**108 700Rs**

PS5

MIDDLE DAIRY FARM
0,5-1,75ha

In blue example of farm
UAL : 1,25ha

Family worker : 2
Family : 6 members

Landowners are interested by dairy sector to improve their income based on grain crops. Most of the time they work on their lands and hire workers when they need. These farms are developed since Sudha's installation (2003). Sudha helps these farmers to buy some improved cows.

Inputs (farm 1,75ha)

Seeds	15 700 Rs
Fertilizers	16 200 Rs
Pesticides	8 600 Rs
Irrigation	14 900 Rs
Food	133 700 Rs
Reproduction and care	2 800 Rs
Fuel	13 200 Rs
Transformation and storage costs	1 700Rs

CS4 RICE/WHEAT/Ø | 1.03ha
CS3 RICE/LENTILS/Ø or RICE/GRAM/Ø | 0.38ha
CS13 MAIZE/MUSTARD/Ø | 0,13ha
CS6 RICE/BARSEEM/Ø | 0,04ha
CS7 MILLET/POTATOES/MILLET | 0,04ha
CS10 RICE / POTATOES / VEGETABLES | 0,04ha

Manure 16,4t ↑ ↓ Fodder Straw

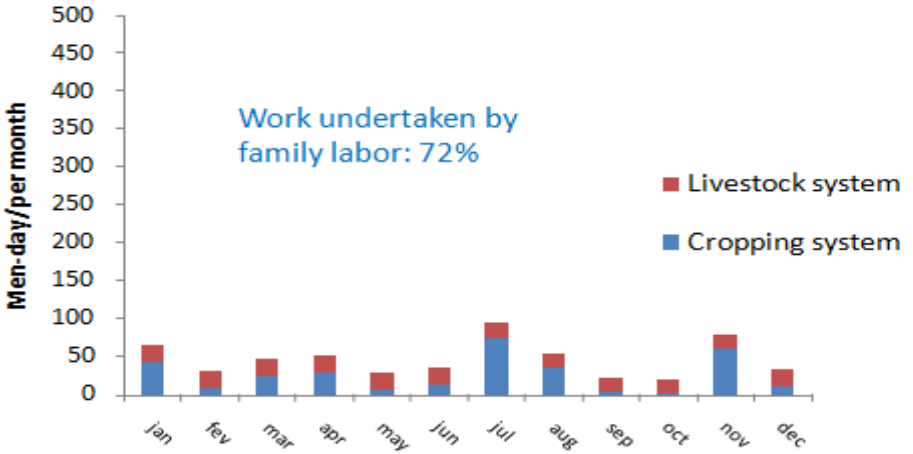
ou LS5 / LS2 CROSS-BREED OR BUFFALOS MIDDLE DAIRY FARM | 4 cross-breed or 3 she-buffaloes

Equipment:
Thresher
1 pumps
Other equipment

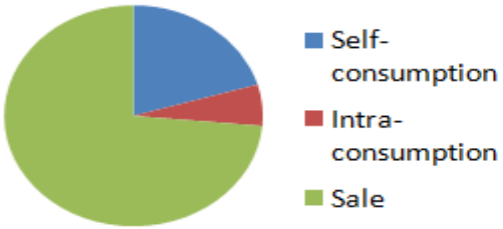
Outputs (farm 1,75ha)

Rice	79 600 Rs
Wheat	37 400 Rs
Pulses	21 400 Rs
Oilseeds	3 100 Rs
Maize	5 600 Rs
Potatoes	6 900 Rs
Vegetables	2 000 Rs
Crop residues	1 600 Rs
Milk	150 200 Rs
Animal selling	30 500 Rs
Manure	6 800 Rs

Exemple farm working calendar



GP repartition (example farm)



GP	365 700 Rs
IC	228 500 Rs
GAV	137 200 Rs
Depreciation	4 200 Rs
NAV	133 000 Rs
Laborers salary	49 200Rs
Taxes	150Rs
Interests	900 Rs
Agricultural Income	**77 500Rs**

PS6 SMALL VEGETABLE FARM 0,375-1,125ha (rented)

Family worker : 2
Family : 6 members

In blue example of farm
UAL : 1ha (0,94ha rented)

Landless or small landowners rent lands to absent owners. They cultivate vegetables to improve their added value. Two people work in the farm. They hire daily workers, seasonally.

Inputs (farm 1ha)

Seeds	41 800 Rs
Fertilizers	28 500 Rs
Pesticides	8 100 Rs
Irrigation	31 500 Rs
Feed	4 500 Rs
Reproduction and care	350 Rs
Fuel	8 750 Rs
Transformation and storage costs	1 400 Rs

CS4 RICE/WHEAT + mustard/Ø | 0,25ha

CS8 RICE/POTATOES / ONIONS | 0,25ha

CS12 VEGETABLES/VEGETABLES/VEGETABLES | 0,25ha

CS11 RICE/VEGETABLES/VEGETABLES | 0,13ha

CS9 RICE/POTATOES/MAIZE | 0,06ha

CS10 RICE / POTATOES / VEGETABLES | 0,06ha

Straw

LS1 SHE-BUFFALOE GRAZING DURING ONE PART OF THE YEAR | 1 she-buffaloe

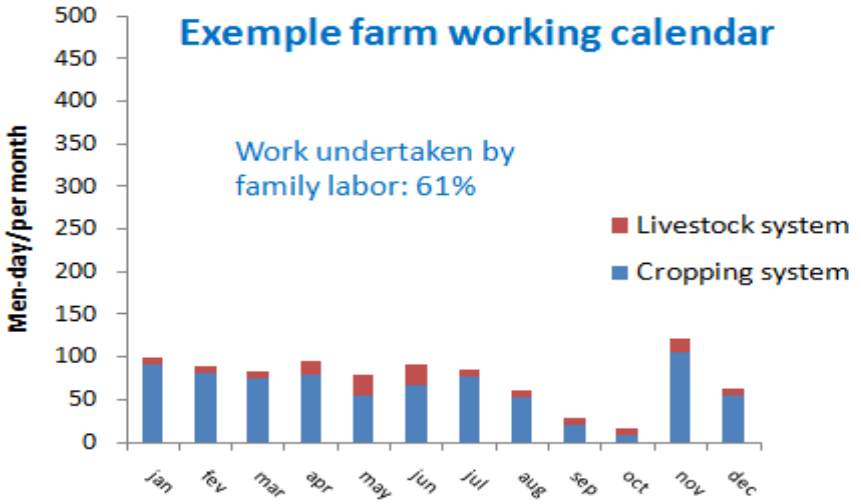
LS8 LITTLE POULTRY | 2 chickens

Equipment:
Other equipment

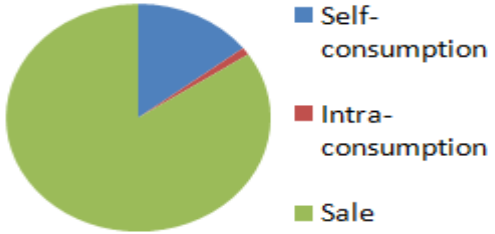
Outputs (farm 1ha)

Rice	35 500 Rs
Wheat	9 700 Rs
Maize	4 500 Rs
Oilseeds	2 800 Rs
Onions	51 000 Rs
Potatoes	46 200 Rs
Vegetables	125 400 Rs
Crop residues	4 600 Rs
Milk	19 600 Rs
Animal selling	7 600 Rs
Dung cakes	6 500 Rs
Poultry activity	2 200 Rs

Exemple farm working calendar



GP repartition (example farm)



GP	319 200 Rs
IC	128 100 Rs
GAV	191 100 Rs
Depreciation	200 Rs
NAV	190 900 Rs
Laborers salary	51 300 Rs
Land rent	30 000 Rs
Interests	3 800 Rs
Agricultural Income	**105 800 Rs**

PS7

SMALL GRAIN FARM and EXTERN LABOUR 0,5-1,25ha (rented)

Family worker : 2
Family : 6 members

In blue example of farm
UAL : 1,25 ha (rented)

Landless or small landowners rent lands to absent owners. They are forced to plant grain crops to pay their rent. These farms hire equipment and water. They do not be part of meeting. They have one cow and sell milk surpluses. They use weeds to feed their cattle. These farmers can have another non-agricultural work (shop...).

Inputs (farm 1,25ha)

Seeds	14 300 Rs
Fertilizers	10 100 Rs
Pesticides	1 300 Rs
Irrigation	15 300 Rs
Feed	3 800 Rs
Reproduction and care	350 Rs
Fuel	9 950 Rs
Transformation and storage costs	1 200 Rs

CS4 RICE/WHEAT + mustard /Ø | 0,76ha

CS3 RICE/LENTILS/Ø or RICE/GRAM/Ø | 0,24ha

CS2 RICE / KESHARI / Ø | 0,13ha

CS1 RICE/ Ø/ Ø//(Ø)[4] | 0,05ha

CS10 RICE / POTATOES / VEGETABLES | 0,01ha

Straw

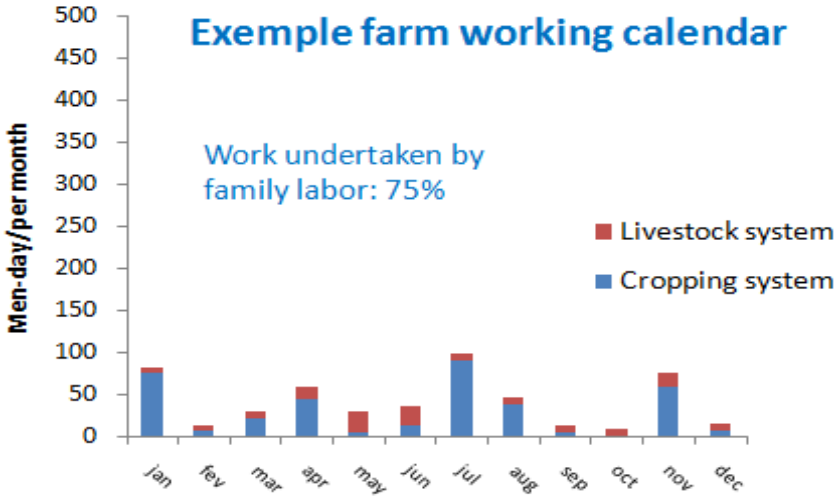
LS1 SHE-BUFFALOE GRAZING DURING ONE PART OF THE YEAR | 1 she-buffaloe

Equipment:
Other equipment

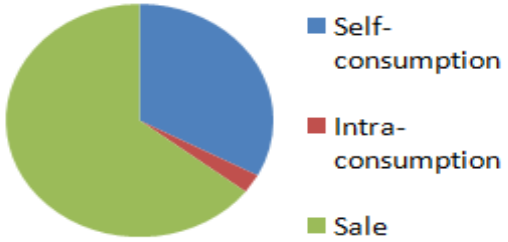
Outputs (farm 1,25ha)

Rice	56 100 Rs
Wheat	27 000 Rs
Pulses	17 000 Rs
Oilseeds	2 800 Rs
Potatoes	2700 Rs
Vegetables	2700 Rs
Crop residues	11 300 Rs
Milk	19 600 Rs
Animal selling	7 600 Rs
Manure	6 500 Rs

Exemple farm working calendar



GP repartition (example farm)



GP	157 500 Rs
IC	60 200 Rs
GAV	97 300 Rs
Depreciation	200 Rs
NAV	97 100 Rs
Laborers salary	21 400 Rs
Land rent	25 300 Rs
Agricultural Income	**50 400 Rs**

PS8 **SMALL GRAIN FARM**
0,5-1,25ha (rented)

Family worker : 2
Family : 6 members

In blue example of farm
UAL : 1,25 ha (rented)

Landless or small landowners rent lands to absent owners. They are forced to plant grain crops to pay their rent. These farms hire equipment and water. They do not be part of meeting. They have one cow and sell milk surpluses. They use weeds to feed their cattle. These farmers can have another non-agricultural work (shop…).

Inputs (farm 1,25ha)

Seeds	7 300 Rs
Fertilizers	5 150 Rs
Pesticides	700 Rs
Irrigation	7 700 Rs
Feed	3 800 Rs
Reproduction and care	350 Rs
Fuel	5 000 Rs
Transformation and storage costs	1 200 Rs

CS4 RICE/WHEAT + mustard/Ø | 0,38ha

CS3 RICE/LENTILS/Ø or RICE/GRAM/Ø | 0,11ha

CS1 RICE/ Ø/ Ø//(Ø)[4] | 0,06ha

CS10 RICE / POTATOES / VEGETABLES | 0,01ha

Straw

LS1 BUFFALOS GRAZING DURING ONE PART OF THE YEAR | 1 she-buffalo

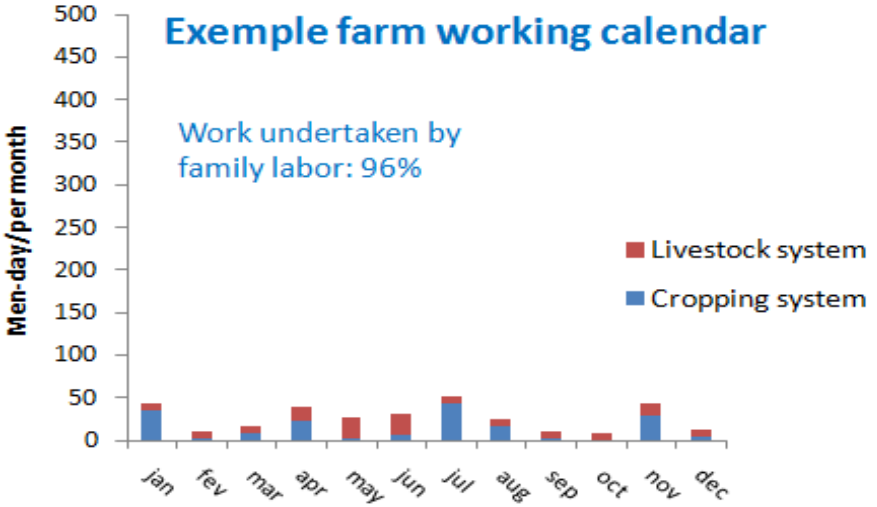
LS9 LITTLE POULTRY | 2 chickens

Equipment:
Other equipment

Outputs (farm 1,25ha)

Rice	27 700 Rs
Wheat	15 300 Rs
Pulses	7 800 Rs
Oilseeds	2 800 Rs
Potatoes	2 700 Rs
Vegetables	2 000 Rs
Crop residues	3 400 Rs
Milk	19 600 Rs
Animal selling	8 900 Rs
Manure	6 500 Rs
Poultry activity	2 200 Rs

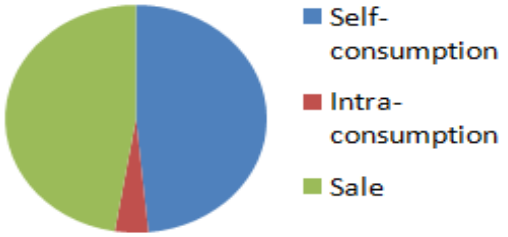
Exemple farm working calendar



Work undertaken by family labor: 96%

Livestock system
Cropping system

GP repartition (example farm)



GP	101 900 Rs
IC	35 200 Rs
GAV	66 800 Rs
Depreciation	200 Rs
NAV	66 600 Rs
Laborers salary	8 100 Rs
Land rent	13 300 Rs
Agricultural Income	**45 200 Rs**

PS9a

DAILY WORKER WITH BUFFALO

Daily workers who have one buffalo. The children or women take care of this animal.

In blue example

Family worker : 2
Family : 6 members

Inputs (farm)

Straw	3 900 Rs
Concentrate Feed	3 800 Rs
Reproduction and care	400 Rs

LS1 SHE-BUFFALOE GRAZING DURING ONE PART OF THE YEAR | 1 buffalo

LS9 LITTLE POULTRY | 2 chickens

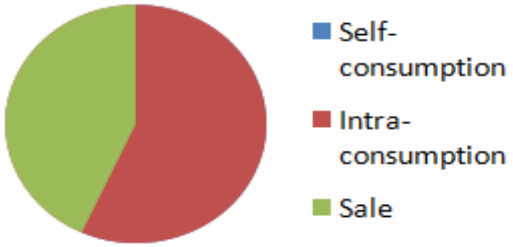
Equipment:
Little equipment

Outputs (farm)

Milk	18 100 Rs
Animal selling	8 700 Rs
Dung cakes	6 500 Rs
Poultry activity	2 200 Rs

Exemple farm working calendar

GP repartition (example farm)



GP	35 500 Rs
IC	8 100 Rs
GAV	27 400 Rs
Depreciation	100 Rs
NAV	27 300 Rs
Agricultural Income	**45 200 Rs**
Other Income	**21 900 Rs**

PS9b

DAILY WORKER WITH GOATS

Daily workers who have not enough money to buy a buffalo. Women take care of 3 goats.

In blue example

Family worker : 2
Family : 6 members

Inputs (farm)

Straw	500 Rs
Concentrate Feed	2 600 Rs

LS7 GOATS | 3 females

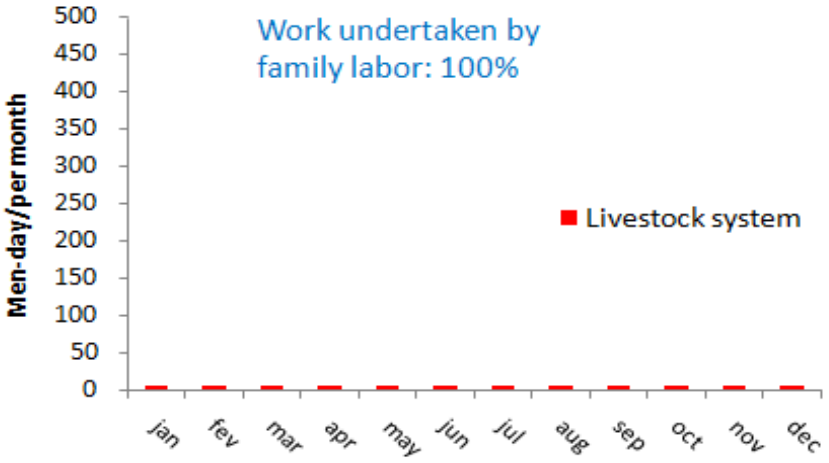
LS9 LITTLE POULTRY | 2 chickens

Equipment:
Little equipment

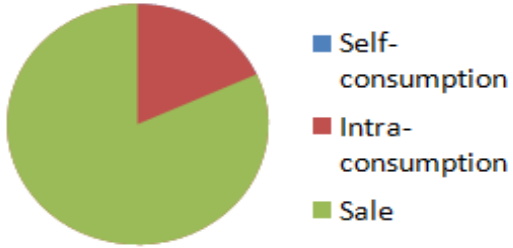
Outputs (farm)

Animal selling	13 700 Rs
Poultry activity	2 200 Rs

Exemple farm working calendar



GP repartition (example farm)



GP	15 900 Rs
IC	3 100 Rs
GAV	12 800 Rs
Depreciation	100 Rs
NAV	12 700 Rs
Agricultural Income	**12 700 Rs**
Other Income	**30 900 Rs**

PS9c

PERMANENT WORKERS + 10 KATTHAS

In blue example

Family worker : 2
Family : 6 members

Owners give ten katthas to these permanent workers. Most of the time they are not able to have good yields because they have to work for the owner of lands.

Inputs (farm)

Seeds	3 900 Rs
Fertilizers	2 300 Rs
Pesticides	600 Rs
Irrigation	3 100 Rs
Oil	1 100 Rs
Transformation and storage costs	500 Rs

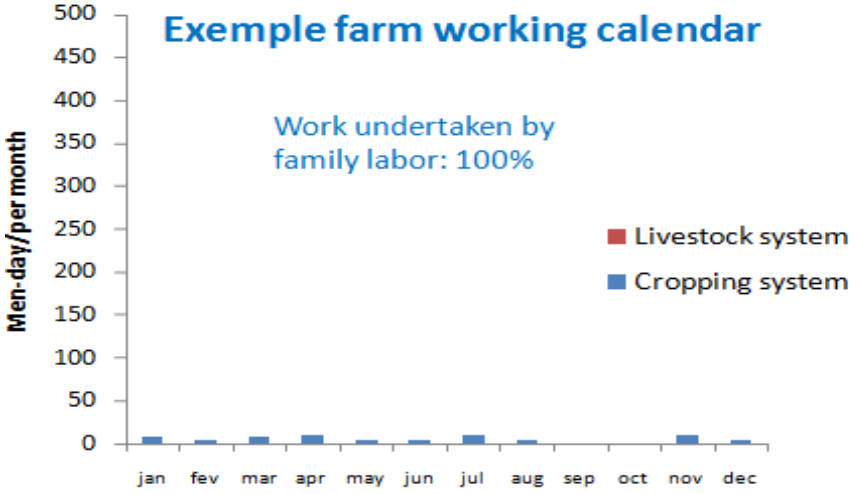
CS4 RICE/WHEAT/Ø | 0,08ha

CS10 RICE / POTATOES / VEGETABLES | 0,05ha

Outputs (farm)

Rice	7 500 Rs
Wheat	3 100 Rs
Potatoes	7 600 Rs
Vegetables	6 000 Rs
Crop residues	1 400 Rs

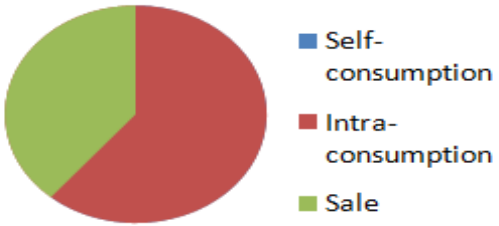
Exemple farm working calendar



Work undertaken by family labor: 100%

Livestock system
Cropping system

GP repartition (example farm)



GP	25 600 Rs
IC	11 500 Rs
GAV	14 100 Rs
Depreciation	0 Rs
NAV	14 100 Rs
Agricultural Income	**14 100 Rs**
Other Income	**48 000 Rs**

PS10 **SHEEPHERDER**

Following their ancestors, they have one herd of sheep. However they could be disappear.

In blue example

Family worker : 2
Family : 6 members

Inputs (farm)

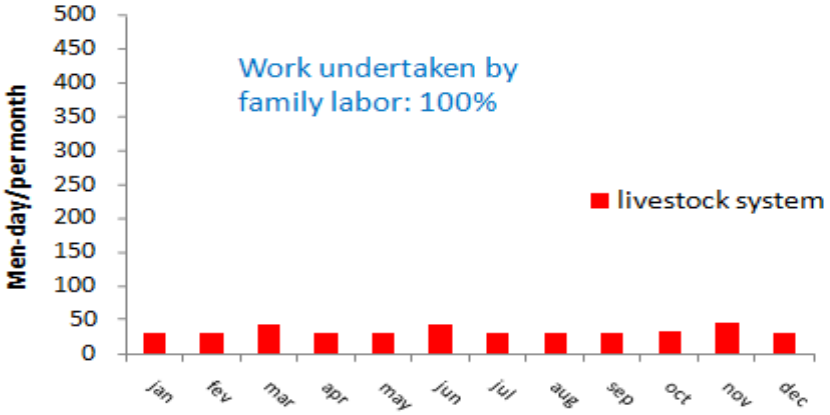
Straw	700 Rs

LS10 SHEEPS | 35 females + 11 rams

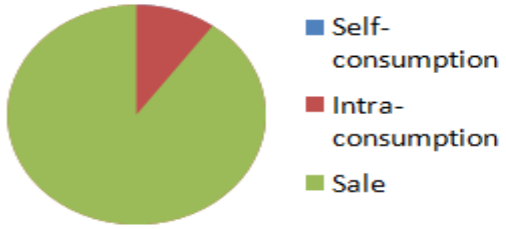
Outputs (farm)

Animal selling	36 550 Rs
Wool	8 050 Rs
Milk	6 300 Rs
Plot fertilization	12 000 Rs

Exemple farm working calendar



GP repartition (example farm)



GP	62 900 Rs
IC	700 Rs
GAV	62 200 Rs
Depreciation	0 Rs
NAV	62 200 Rs
Agricultural Income	**62 200 Rs**

6.2.Comparative analysis

6.2.1. Note to read graphs

Before to present three graphs analyzing economic results, some explications are given.

- The minimum and maximum surfaces are not calculated but estimated from observed farms. However, the maximum surface is coherent with the human capacity to conduct these systems (especially for systems without hiring of laborers).

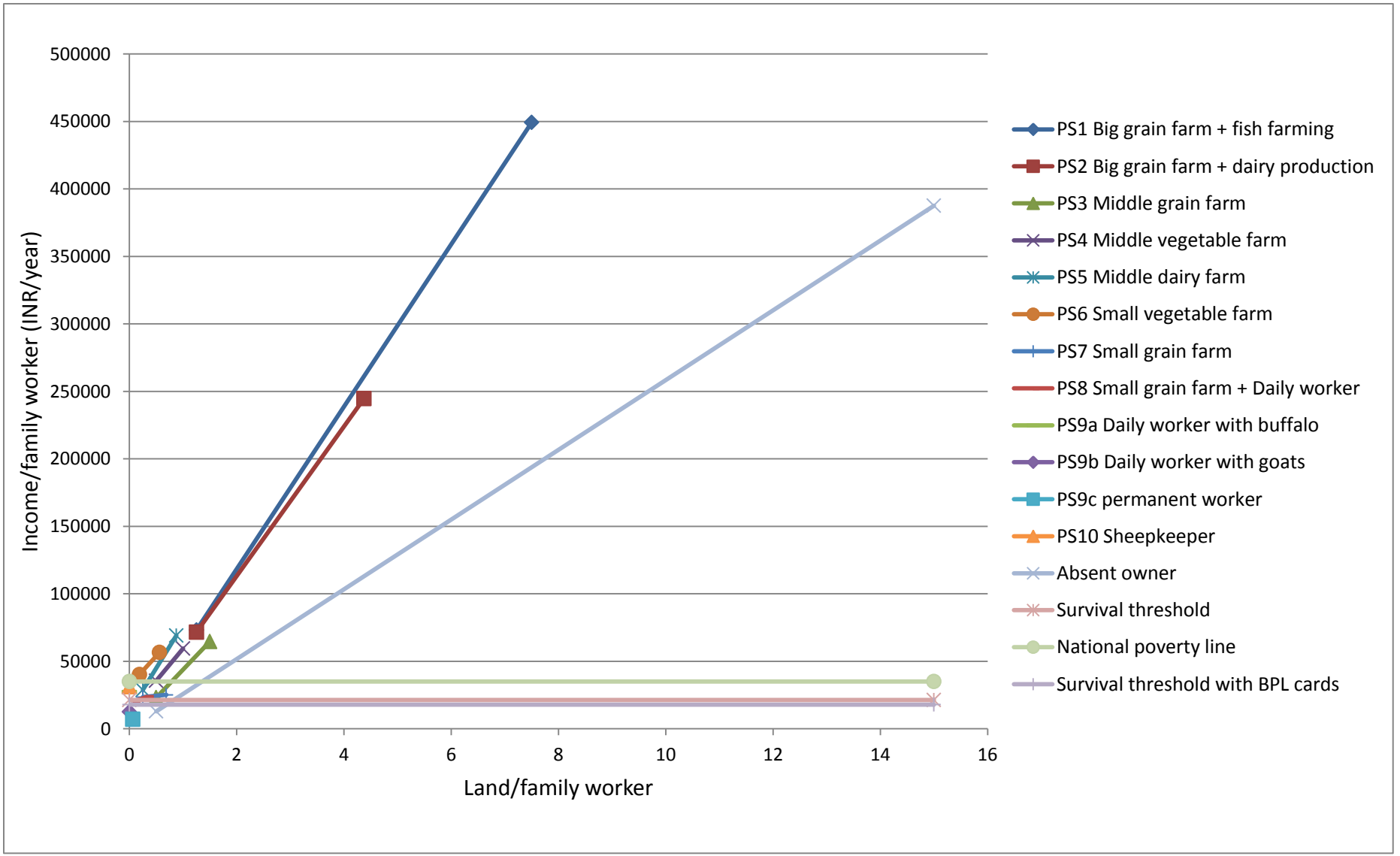
- We have supposed that linear function characterize each production system. These linear functions depend on land surfaces and intercept of the regression represents depreciation of equipment. Cropping system depend on land surfaces, however we have defined that livestock systems are not directly link with surfaces.

- The poverty line presented is that recently calculated by an Indian expert group, which estimates the value of INR 32/person/day in rural areas. In order to consider the positioning of the different types of farm in relation to this poverty line, we will estimate the income of a family with two parents working on the farm, their three children and one husband's parent. This form of organization of family, called joint family, is the most common in India. We consider that there are two workers per household and two people depend on each parent. Thus, the poverty line per active labourer will be INR 32 x 365 x 3 = 35 040 INR, or per family it will be 70 080 INR[38].

- We have calculated a threshold of survival, which estimated minimum supply, hygiene and health needs. In order to value this threshold, we use market price of Ekangar Sarai block. For a joint family previously described, it is 42 750 INR/ year or 21 400 INR/active/year.
  Then, we have calculated a second threshold, including prices which are available with BPL card. This threshold is 35 800 INR/year for a joint family.

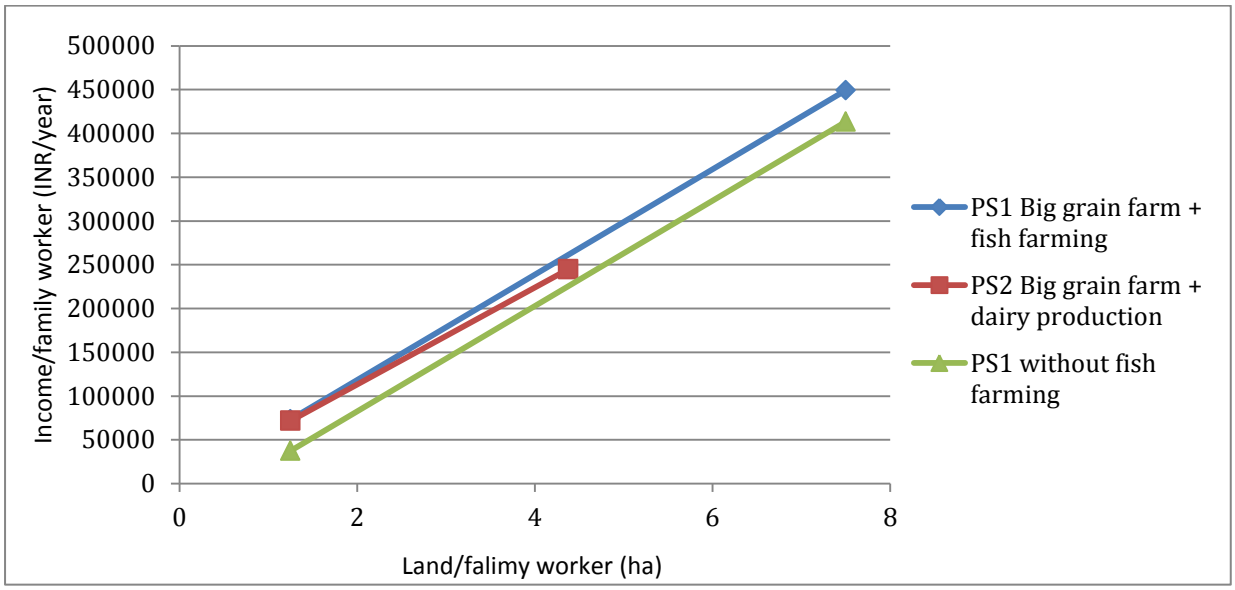
  BPL card allows poor people to have access to essential products (rice, wheat and fuel oil) at a lower cost. Thus, they can buy 15kg of rice per month at 3INR/kg, 10kg of wheat per month at 2Rs/kg and 3litters per month at 30INR/litter.

[38] Appendix E



Graph 19 : farm income per family worker according to the farm size per family worker

From the graph above (graph 19), we can divide production systems in two groups. The first group includes big farms and the second all the other systems. Indeed, income of big farms is significantly higher than the others. By comparing PS1 and PS2 to a hypothetic system of big farm (PS1 without fish farming), we highlight livestock has a great importance in order to increase income of these farmers (graph 20). Furthermore, the difference in income between PS1 and PS2 is partly due to the difference of cropping system. The production system 2 has to include more cropping systems with fodders. And systems with fodders do not produce wealth.



Graph 20 : Importance of livestock rearing system in big grain farms

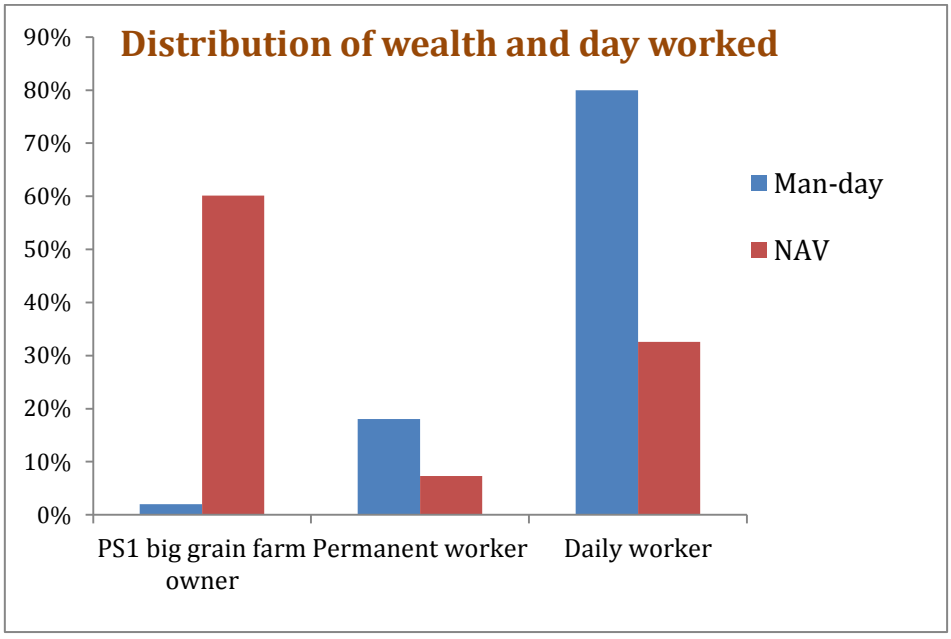
The choice of big farmers to focus themselves on dairy production depends of their free time and their interests. Indeed, these farmers are most of the time recently retire, have time. However, the graph shows that this specialisation do not allows an increase of income in comparison to PS1. Indeed, it is important to note that fish farming enables an increase of income, without a great increase in working time. However dairy production needs lots of labour. Moreover these systems are new, and not stabilize. Farmers are able to improve yields of this system. Furthermore, today it is a step, in the future, some farmers of PS2 wish to increase their herd and develop milk processing on their farm. This diversification would increase their income. Moreover, they want to emancipate themselves from the Sudha cooperative, and to have their own market. Milk prices could be higher.

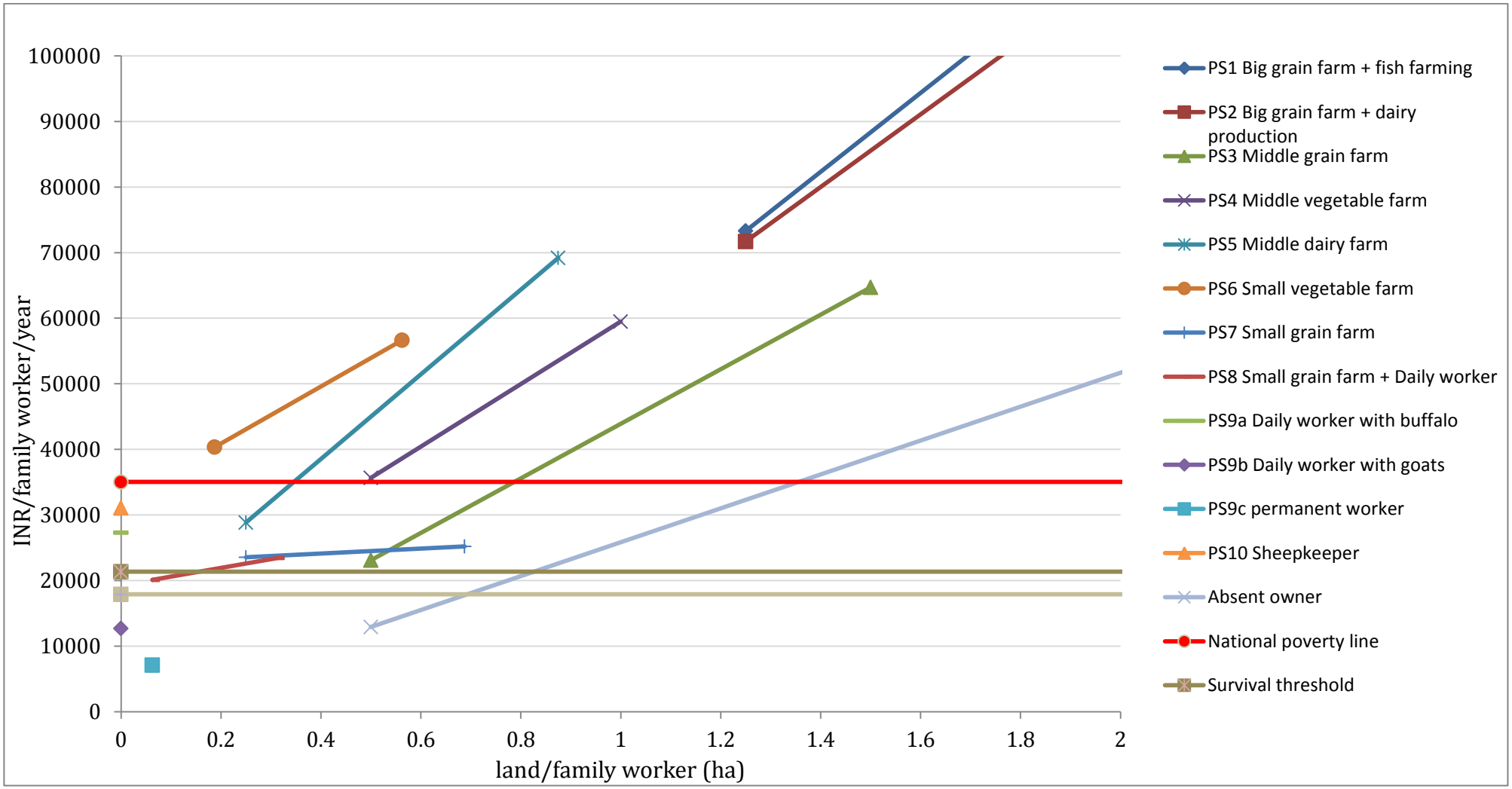
Concerning grain production, some farmers of PS1 are at the cutting edge of equipment. As we have seen, they begin to use seeder combined with a fertilizer spreader. This machine allows them to reduce the quantities of seeds and fertilizers. The widespread use of this machine could lead to the decrease of intermediate consumption.

Calculation of wages

In order to calculate the total wages a farmer has to pay, we have taken into account a fixed number of working days done by the owner. The rest is done by permanent (PS1 and PS2) or daily labourers.

Thus, we can note a significant variability in amount of work done. The graph below shows the amount of work according to the wealth generated. For PS1, owner of lands get 60% of wealth and does only 2% of the farm work. In contrast, daily labourers do 80% of farm work and receive only 30% of incomes. We can say that farms of PS1 are capitalist.





Graph 21 : Focus on graph 2

The zoom on the other production systems (graph 21) shows that the specialization toward dairy production, at the middle farm level, allows a strong increase in income as well.

If we compare PS3 and PS5, we note that dairy farming (which is non-proportional to the surface) increase incomes. Moreover, the slope of the straight line of PS5 is more important. Indeed, farmers of PS5 work on the farm more than farmers of PS3. Thus, farmers of PS3 have to hire more daily labourers than farmers of PS5.

Another way to increase agricultural income seems to be development of market gardening production. Indeed, we have seen that vegetable production is more profitable per hectare than grain crops. PS4 which produce more vegetables than PS3, have higher incomes. However, their incomes are lower than that of PS5. Even if they produce vegetables crops, they still grow grain and legume crops as well. Moreover, farmers of PS4 hire more daily labourers than farmers of PS5.

Similarly, at the small farms level, market gardening enables an increase of incomes. If we compare PS7 (grain production) and PS6 (gardening production), we note that income of PS6 is higher than that of PS7 because PS6 grow more profitable crops per hectare. Although farmers of PS6 hire more labourers (labourers do 34% of farm work in PS6, whereas they do only 25% in PS7), it does not offset the advantage per hectare of PS6. Now if we compare PS6 and PS4, the difference is due to the share of lands planted in vegetable (around 75% for PS6, and only 40% PS3).

Slope of straight line of PS7 is extremely low. It can be explain by the fact that the rotation [paddy/∅/∅]// [∅] [4] occurs frequently. We have to link this information by the fact that this farmers receive low quality lands.

Incomes of PS7 and PS8 farms are lower than poverty line, fixed by Indian government, and border the survival threshold. Indeed, due to a lack of access to the means of production, the net value added of these farms is low. These farmers are not owners of their lands; they have to do crop rotations which are not profitable per hectare (grain crops) in order to pay the lease. Moreover, they have an irregular access to water, with a consequent decrease in yields. The obstacle to a transition from this production system to a market gardening system is the location of farms. Indeed, we have seen that all areas are not conducive to vegetable production. This production depends on access to water and infrastructures.

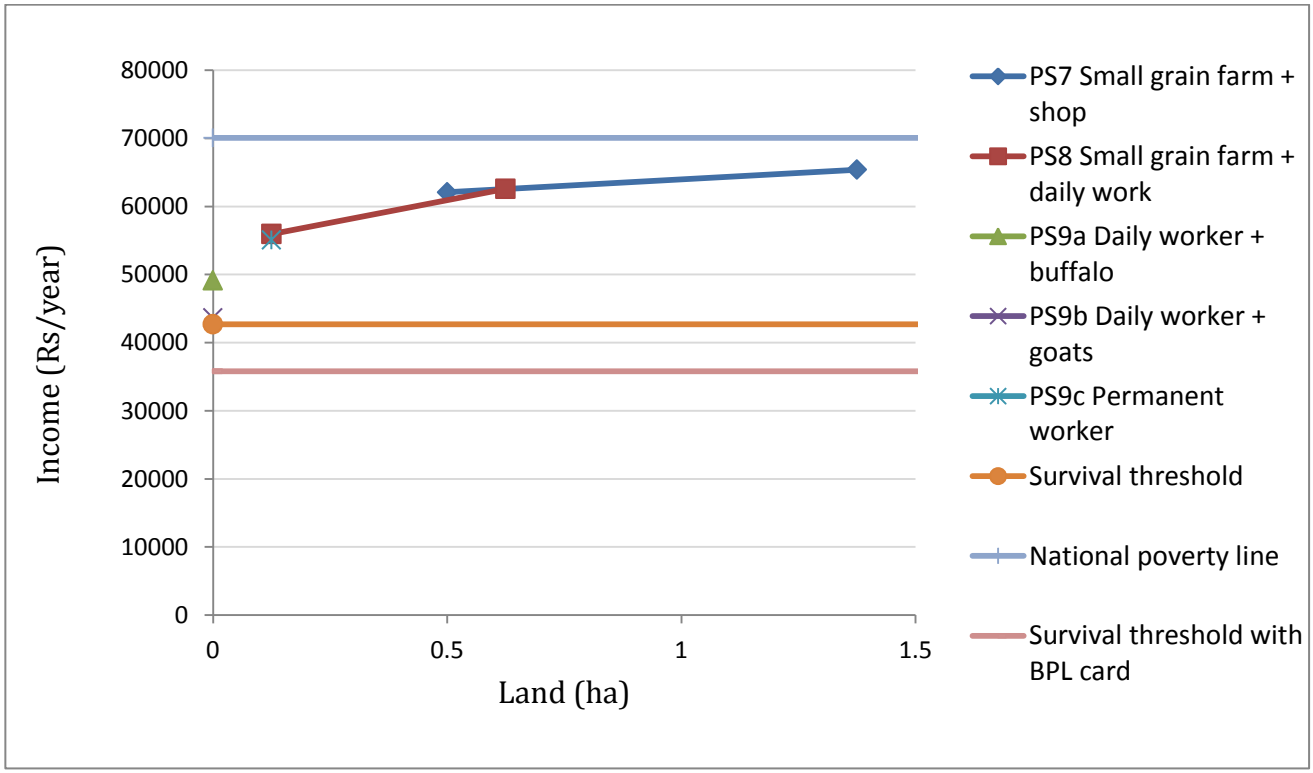
Slope of straight line of PS8 is higher than that of straight line of PS7. Indeed farmers of PS7 have low fertilise lands and farmers of PS8 have more fertile lands because they have more links with the landowners. Moreover, farmers of PS8 do 96% of farm work, whereas farmers of PS7 do only 75%. Thus, farmers of SP7 have to hire more daily labourers. In order to supplement income, these two types of farm have non-farm work. Generally, farmers of PS7 are shop keeper and earn about 5 000Rs /month. Farmers of PS8 are daily labourers or work in brickyard a part of the year. If we compare PS7 and PS8 with PS3 the difference o slope is due to a difference of yields. The two systems of small farmers have worse yields.

On the graph, we can see landless' income as well. This income is only due to livestock farming (PS9a, PS9b and PS10). PS9c are permanent labourers. Owners of lands who hire them give them 10 katthas of land where labourers can cultivate. Thus, income shown on the graph only

takes into account income from the cultivation of 10 katthas. All landless live below the poverty line.

The comparison of PS9a and PS9b underlines the economic interest to have a she buffalo rather than goats. Income from buffalo rearing is twice higher than that of goat rearing. Goat rearing is below the survival threshold. We have already explained the challenge to move from PS9b to PS9a. It needs an important investment in order to purchase a she-buffalo, and farmers of PS9b cannot afford it.

In order to compare all production systems which include non-farm work, we have calculated an average income per household (graph 22). In addition to the farm income, this indicator takes into account non-farm income (shop keeper, daily labourer, worker in brickyard).



Graph 22 : Total income (farm income and non-farm income)

On this graph, even if we take into account the average income, including non-farm incomes, all production systems are still below the poverty line. But thanks to these non-farm incomes, all are above the survival threshold.

We can see that the economic advantage of the bovine breeding decrease when we take into account the average income per household. Indeed, this activity needs more time than breeding of goats. Landless who have a she-buffalo cannot work outside the farm as much as farmers who have goats. Thus, even if incomes of farmers who have goats stay lower than that of farmers who have a she-buffalo, it reaches the survival threshold.

We can also note that permanent workers earn more money than these daily workers. However, unlike daily workers, permanent workers are subjugated to owners of lands.

If we come back to the graph 21, we can observe that the income of shepherd is below the poverty line as well. In the past, as we have seen, they were paid in order to stay on field to renew the soil fertility. However, nowadays, fewer farmers ask for them. Their income from this activity decreases.

Prospects

In the following part we will discuss about the development perspectives. First we are going to focus on the sustainability of cropping systems, livestock systems and production systems faced with the future. Then we will develop some reflexions which could help to improve agriculture. At last, we will speak about some problem in Bihar.

Crop prospects

For a long time, farmers have grown crops, which evolved and tried to be more adapted to situations. Politics have also been able to influence these changes.

Rice and wheat two attractive crops

Nowadays, when farmers are asked what the main crops are in your block, everyone will answer paddy and wheat. Paddy crop cover more than 90% of the landscape during rainy season and wheat 70% during winter season. Wheat crops are always in rotation with paddy crops. Nevertheless paddy crops are able to be associated with other crops. Extension of these two crops is due to different facts. The first is the green revolution and government policies. Green revolution allows developing land cover with these crops. The second explanation is the role of paddy and wheat in human diet. In rural areas, they are the basis of Bihari diet. People eat everyday rice and bread (wheat flour). Besides, farmers use these products to pay rents. Therefore some farmers are obliged to cultivate these crops. Yield can also explain this observation. Indeed farmers prefer crops with high yield. At the harvesting time, it is more impressive to harvest wheat and paddy than other crops. Moreover today yield of these two crops seem to be more secured. Other crops are more affected by diseases and yields more fluctuating. Last but not least, prices are fixed. Indeed, government buy these two products in order to redistribute them through the Public Distribution System. This limits enhancing the value of products in market which depends on supply and demand. It is not the case for the other products like vegetable and pulses.

However these two crops require lots of inputs. Moreover, farmers have noted that paddy and wheat crops damage soils. Price of seeds increases, and taste decreases. For five years, diseases and pests have also increased. These have a direct impact on the yield. Farmers reach the limits of monoculture. Growing each year the same crops on the same plots increase resistances of pets and fungi. Farmers have to care about this point. We will try to discuss how in following parts.

If we include all these point we think that the number of plots planted in wheat and paddy will firstly decrease. However they will stay the more important crops of Bihar state.

Market gardening farm faced with the future

In this report we have seen that market gardening farms allow farmers to intensify their production. On the graph 10, we see that farmers who plant vegetables have better economic outcomes than the others. However just some parts of the block are suitable for market gardening cultivation (sandy soil, water availability, area served by a road, no “vegetable predator”). It is the challenge. Can we improve growing of market gardening, and are these cropping systems suitable for the future?

Improve vegetable production

We have seen that several factors led to a decrease of market gardening cultivation ten years ago. These factors are the competition with two others areas around the cities of Patna and Bihar Sharif, damage caused by nilgai, lack of marketing sector and price fluctuations. However some factors could change or be changed.

Firstly, government have to help farmers to fight against Nilgai. These damage occur because men and nilgai share same environment, and men destroyed natural habitat of nilgai but not only. Number of nilgai increases every year. They have no predator and have all the feed they require. Therefore if nobody does something, conflict areas will increase. Introduce a new predator is impossible in the study area. Government have to create plan to limit the number of this animal. Farmers also can do some actions. A small number of farmers have decided to fence their fields with electric cables. Nevertheless it is very expensive and not suitable for big plots. Maybe, farmers could scare away the mammals thanks to dogs. Moreover they could use some olfactory plants. Farmers could grow these plants in the edges of plots.

Nowadays the two markets of Patna and Bihar Sharif are very powerful and developed. They flood the other city with their production. Faced with this, farmers are so small. However some farmers try to organise informal market. It could be a solution. Some farmers have chosen to sell their vegetable in their village. This limits transport costs, prices could be under market price and higher than middle men price. However this is suitable for a small quantity of vegetables. If the entire village produces vegetable there will be surpluses. That is why middle men are not a bad solution. They group production of farmers together and deliver a big quantity of vegetables. Nevertheless we have to limit the number of these intermediates. If it is too important, price will be not sold to a good price. NGOs have to study the market organisation and demand (in Patna or other big cities), in order to know if consumers could be interested by processed products and which products. Then, they still have to find investors and government support. The aim is to create a new field where a factory could be established in the local area. This could create job and demand for vegetables. Prices will be also defined and fixed.

Government have to develop the area. Indeed, some farmers can grow vegetable because they live in remote areas. Middle-men are not interested to go in these zones because they lost lots of time. Government should create better roads to open the area. It is also essential to maintain used equipment like cold store. Another cold store could be created to preserve onions. Indeed, Farmers in the hope of obtaining better prices, farmers have an interest in selling their production later, and not just after harvesting.

A suitable production

We have glimpsed that it is possible to do some actions to increase vegetable production. However we have to know if it is adapted to future challenges.

Farmers use fertilisers and lots of pesticides to grow vegetables. With the impoverishment of soils and increase of pest pressure, farmers will apply more and more chemical fertilisers and pesticides. In order to limit this, they could mix different type of vegetables. Moreover in the case of an increasing of the production, farmers have to preserve their soils.

To conclude we can say that the next two to three next year vegetable production will be decrease. This year prices are not good and demand is absented. Moreover farmers have more

and more problem with nilgai. Then, production will increase again, because market gardening systems have still better economic outcomes.

Pulses temptation

During our study, legumes prices are very interested. Moreover farmers have noticed that paddy yields are better after pulses farming. Besides, pulses do not require lots of water and inputs. The graph 10 confirms this observation. Pulses have good economic outcomes. Therefore, we can think that pulses production will be increase next year. However we have to make several points clear. Pulses do not resist to water excess whereas for 5 years precipitation have increased in winter season. Thus, farmers lost a part of their harvest. Moreover farmers do not self-consume a large quantity of pulses. Last but not least, wheat could be more interesting, at the expense of pulses. Indeed, farmers hope to reach yields predicted on wheat packet when they purchased the seeds. This could encourage them to grow wheat instead of pulses.

Next two years rotation with pulses will increase but very few. After, this will stabilize.

The aim of increasing yields

When people try to find a solution to increase the gross value added, they speak about yields. We can approach this suggestion. However, we have to be careful with this proposition. Indeed sometimes it could be a solution. This is true for the small farmers who have poor yields, and who cannot irrigate their crops. Indeed, just providing the opportunity to have water, without increasing the quantities of fertilisers or pesticides could be a solution in order to increase yields. That is also true if farmers try to improve their yield with agro-ecological methods, without change varieties or increase input (rotation, association, manure, preservation of soil…). However, it is more difficult if we try to increase yield by increasing quantity of fertilisers or changing seed varieties. Indeed if farmers use more fertilisers in order to increase yield, they will have to assess if profit margin of yield could offset the price of fertilisers added. Even if it is the case, they damage soils and the following year they will have to increase fertiliser quantity to keep equivalent yields. If farmers grow high genetic varieties, crops become sensitive to pests and fungi and they have to use more pesticides to protect them as well.

Damaged soils

During our internship, we have worked in field with farmers. We observed the lack of organic activity in soils. In the study area there is no warms and microorganisms in soils. Since 1970 and the beginning of green revolution, farmers have increased by ten the quantity of fertilisers apply in one year. Moreover nowadays they grow to three crops per year. That means there is a constant extraction of nutrients. In order to provide nutrients to soils, farmers apply fertilisers in their fields.

Some farmers realise that soil is their fundamental tool. They have to preserve it. They have to use less fertilisers and more organic manure and compost. They also have to care about warms and microorganisms. These organisms are able to aerate the soil and ease the decomposition of organic matter. Thus, nutrients are easier roots.

Monocultures issues and importance of keeping diversity

Fifty years ago, farmers tried to diversify their production and mix crops. Today, most of farmers grow one crop per plots. Each year, they grow the same crop in the same plot. For 5 years, due to the lack of diversity, the number of pest damage has increased, especially locust plague. Grasshoppers damage maize, fodder and vegetable crops during the beginning of summer

season. They eat leaves and grains. Farmers do not harvest their crops because it stays nothing. Moreover pesticides have no impact on these animals. Even if is not only due to the monoculture, this practice could lead to this phenomenon. Another example can be given. Paddy is damaged by more and more fungi for 2 years. In order to limit resistance, they have to grow different varieties of paddy from one year to another. This practice allows breaking the cycle of infection. They also should limit the number of pesticides in order to increase number of partridge. Indeed, partridges eat pests and grains, and could be killed by pesticides. Maybe, thanks to a limitation of pesticide application and the implementation of a breeding program, their number could increase.

Besides, through monoculture farmers loose diversity. If they want to cope with future, they have to preserve it. Indeed this diversity offers to them more resistance to diseases and pest attacks, and more adaptability to a changing environment.

Rotations and legumes

There are two types of rotation: inter-annual rotation (between two years) and intra-annual rotation (in the same year). As we have seen before, Indian farmers use few inter-annual rotations. Indeed, they apply each year the same intra-annual rotation on a same plot. So, farmers have to be careful. Rotations could be useful. They allow preserving soils and soils and decreasing pests and fungi resistances. Moreover, some inter-annual rotations allow increasing yields. Some farmers know this fact they do the following rotation: paddy/wheat/fallow//paddy/pulses/fallow. They have seen that yields are better. Moreover they apply fewer pesticides and fertilisers on their plots.

Furthermore, in intra-annual rotation, farmers include legumes which allow renewing soil fertility. Indeed, pulses fix atmospheric nitrogen in the soil. It allows farmers to use fewer fertilisers and to protect soil against damage and exhaustion.

Farmers must not forget that intercropping is interesting. Indeed there are interactions between the two crops: one crop can protect the other, and a crop can fix nitrogen and the other use it. Thus, yields can be better. We have seen lots of examples in the study area. Mustard protects pulses against cold temperatures and pulses fix nitrogen. Rapeseed protects wheat against nilgai and pests. However it is better if there is no competition between the two crops for light, nutrients and space. The most appropriate quantities of seeds have to be determined.

Big farmer as the leaders

During our study we have seen encouraging signs, especially set up by big farmers. Indeed they have more lands and more means so they can experiment new practises. If it is a failure, they have enough money to pass the year. On the contrary, small farmers and sharecroppers do not want to change their practices because they are afraid to have worse yields. They do not have money to overcome low yield.

The biggest farmers apply manure in their plots. This manure is cheaper than fertilisers and it preserves soil and renews organic matter. However we cannot say if yields are better because they do not use the same seeds, fertilisers and quantity of pesticides as the smaller farmers. They also grow some green fertilisers like Australian moong been. Some of them do not use fertilisers at all. At last, some big farmers do their own varietal selection in order to preserve diversity and prevent disease.

Towards new cropping systems

We have questioned the possibility to grow new cropping systems the next few years. With the increasing of labour costs, some landowners think to cultivate fruit trees (banana, mango) like in north Bihar. However, the study area is not suitable for these trees. Climate and water availability prevent these plantations. Some farmers have tried to implement this cropping system but they failed. It is hard to predict if cropping systems will appear or disappear. We just can say that poor people want to keep the diversity of existing cropping systems because they need all products for living.

More and more mechanisation

In the coming years, mechanisation will follow to increase. Big farmers say that there are not enough labourers so they have to buy tractors, sower, etc. More and more farmers use the combine machine in order to harvest wheat and even paddy crops. Farmers think that thank to mechanisation they can improve their gross value added. However mechanisation damage soils. Indeed tractors are not appropriate for this area. Plots are small and there is no space to reach plots. So when farmers use tractors they mash crops and destroy border of plots. It is the same observation for combine harvester. Moreover there is conflict to use this machine. Big farmers seem to be privileged.

Prospects of livestock rearing systems

After having talked about cropping systems, we will discuss about livestock farming systems. In the entire Ekangar Sarai block Sudha cooperative is presented. In each village there is one collect centre. Are there all factors to increase the milk production?

A Sudha monopoly

Since 2003, the role of Sudha dairy cooperative has grown. More and more village collect centres have been created. Milk quantity delivered has increased. In order to rich this result Sudha helped to create village collect centres. The cooperative gave some machines to test fat quantity. They also tried to fix prices in function of market. They increased price according to inflation. Moreover, they have applied a sliding scale of price. Farmers who rear Indian cows which produce fattier milk, sell their milk at a higher price. Sudha cooperative collect all the milk. So they have to deal with different types of milk, with different fat content. All this milk diversity allows producing dairy product. It is a significant amount of work. Besides they helped small farmers and landless to buy cow. They gave some subsidies, 50% of cow price.

Sudha wants to follow their huge work on the same way. They want to create more collect centres and collect more milk. It seems that there is no limitation. Farmers can sell the quantity that they wish. This aspect is important because farmers are aware that they can increase their milk production and there will be a purchaser. Moreover if farmers need some advices, Sudha can provides them. If farmers do not have concentrate feed Sudha sell concentrate to fixed price. Farmers are aware that dairy sector is secure.

However this monopoly can create some problems. Indeed Sudha have blocked the competition. Other cooperative societies have tried to develop a dairy activity, but they were not able to survive. Sudha cooperative notoriety is too much important. Farmers have preferred give milk to Sudha. Nevertheless, competition is not bad and some farmers have understood this point. Indeed if another society emerges in the study area, there will be a competition and each society would like to have the bigger milk quantity. For reach this aim they will increase prices.

Moreover informal market could be a good opportunity. Prices are higher than Sudha cooperative prices. However the variation of milk production is an issue to this market. Indeed quantity can be divided by two according to lactation periods. So farmers have to adapt the supply to the demand. And sometimes consumers do not understand this point. They want to be able to purchase milk every day.

Milk production may increase in short term

In the study area, more and more farmers are interested by milk production. On one part, farmers see that grain and vegetable prices fluctuate and milk price is fixed. They think that with more productive cross breed cows they can improve their added value. On the other hand, landless know that milk production is an opportunity. They try to buy she-buffalos which are more resistant and can graze. Moreover cow breeds change. Farmers replace indigenous cows by highly productive cross-breed cows. As a result, we think that milk production may increase, the next five years. However this increase could be not linked with a rise of number of milking animals.

How to help the increasing of milk production

We have seen that with existing infrastructures, milk production may increase the next five years. However if we want to improve this rise two options could be studied:

- Increase in the number of dairy animals
- Increase in the genetic of dairy animals

We will discuss about these two opportunities.

Increase in the number of dairy animals

In order to produce more milk, it may need to raise the number of animals. These animals could be reared by big and small farmers. On one hand, we hear everywhere livestock is the wealth of the poor. So if we allow landless and small farmers to buy one or two cows or she-buffalos, these farmers could self consume a part of their production and sell the other part. On the other hand, if middle and big farmers receive support in order to buy others cows or she-buffalos, they may choose highly productive animals and they may sell their milk or a part of their milk to Sudha dairy. By this way, milk production could be improved. Moreover, we have seen that there is enough straw produced in Ekangar Sarai block to feed bovine. This prospect concerns all social categories.

However this option could create more pressure on spontaneous fodder. Indeed landless and small farmers, harvest weeds on the edges of plots or roadsides. If there will be more animals, it will require more spontaneous fodders. However, in the study area there are just few remaining lands. This option could also create an increasing of concentrate feed consumption. This does not cause difficulty in the study area. However in Uttar Pradesh where concentrate feeds are made, it could be an issue. Moreover, the fact that more animals are fed with crop residues means that more greenhouse gases are emitted. Last but not least, it is necessary to find funds required for this option. Maybe another cooperative may launch this project to complete Sudha dairy cooperative and create a new chain.

Increase in genetic of dairy animal

We have seen that increase the number of animals could be not suitable. Thus, another prospect can be studied. It consists in selecting animals with higher productivity, without raise their

number. This means introducing more highly productivity indigenous or cross breed cows in the study area. Introducing cross-breed cows put aside small farmers and landless. They cannot feed these cows. They have she-buffalo and indigenous cows because they are able to graze and to eat a big share of crop residues. These farmers cannot grow fodder and buy concentrate feeds. However this option is interesting for middle and big farmers. These people have enough money and better response to changes. It could be not necessary to grow much more fodder, but only give more concentrate feeds. These cross-breed cows could lead to milk with the same fat content. It could be easier to process. Moreover, it is easier for veterinarian to treat same type of cows. Feed ration type could be proposed as well, in order to help farmers. However, the prospect leads to a loss of genetic diversity, which can bring about development of disease resistances. Furthermore, the issue of space to feed animal is referred to states which produce concentrate feeds.

We have seen that there are pros and cons in each option. Maybe solution is a combination of these two options. However, we have to look if the chosen prospect is suitable faced with new challenges. Indeed, if subsidies are withdrawn, this prospect must to still be sustainable. It is important to identify the impact on the other sectors and other states (which produce concentrates). Last but not least, it is necessary to bear in mind that more animals mean more calves and cull-animals. And in India it is a key question. Beef sector should be developed or we have to use only buffalo for the dairy production, which could be eaten by a part of population or export to other countries.

Keep diversity

Nowadays more and more farmers want to buy a highly productive cow. It is a sign of wealth. Just few indigenous cows are still present in the study area. Forty years ago, genetic diversity was more important. Diversity could be an advantage. Animals are more adapted to the area and the possibility to cross animal is better. Moreover animals are more resistance against disease. Indigenous cows and she-buffaloes can digest spontaneous fodders and crop residues more easily than cross-breed cows. According to Indian people, eating low quality fodder allows these animals to produce milk with more fat and tastier. Therefore, India should keep this diversity, which could face with new challenges.

About other livestock rearing systems

In the study area lots of other livestock rearing systems are present. Most of the time, they are reared by scheduled castes. These animals allow them to earn money to get through the year. Nevertheless some big farmers rear animals such as fish and chicks. On one hand, livestock farming systems reared by scheduled castes will remain the same. They will not increase because there is no demand except for goat meat. However, this meat is only purchase by rich people, who are decreasing in number in rural area. In order to increase goats farming system it is important to organise the supply, collect goats in villages and carry them to cities where there is rich people and demand. On the other hand, those reared by big farmers will increase. Poultry farms function like a company. Owners hire permanent workers and just come one hour per day to see if all it is right. They want to maximise their production (more chick, more input, more benefit). Observations are a bit of different for fish farming. Landowners have chosen to dig their plots in order to create a pound. Every year, they put fry once and wait until they are developed. This activity does not required much time and farmers make lots of profit. However this activity is only possible where water is available.

Production system faced with the future

After having developed some change might be occurred, we will try to project the different system in future. We will explain our point of view to know which system is suitable for the future. Our conjecture regards what we have seen and farmers feeling.

PS1

One farm representing this system is present in each village of the block. Owners are between 45 and 55 years old. Their activity will remain the same. Maybe some farms which do not have fish farming will developed this livestock rearing system and some of them try to develop a dairy production but these questions are asked for 5-6 farms not more. Other farms will buy more machines for grain production. They will not change their cropping systems because they need all the products for their comfort. However after 10 years this production system may decrease. Indeed, children's farmers are not interested to carry on the family farming activity. They prefer to live and work in city. Therefore, they will rent the lands.

PS2

Nowadays, only about four farms are present in the study area. As we have seen previously, they were grain farm which have decided to develop milk sector for three years. It is a new activity. However their number will not increase. Firstly, farmers who have farms of PS1 belong to the Kurmi caste and they are not really interested by dairy production. They prefer to rear fishes rather than cows. Secondly, in this production system, owners work more than in the previous production system. Farmers who choose this system project their farm in future and hope that milk price will increase. Thirdly, they have no space to rear more animals, and building a new cowshed is expensive. For all these observations, we think that only three to four farms will change even if there is a big increasing of milk price.

PS3

We think that this farm will decrease. It is difficult to do profit for the farm owners. So, a part of them may rent their land to other farmers. And the other part may try to develop a dairy sector. Lots of farmers we met said that they want to purchase two or three cows because milk prices become more interesting than grain price. According to them, milk production fluctuates less than grain production which depends of yields and market prices. However, farmers who want to develop this activity need money to purchase cows. The richest farmer of this production system may try to do fish farming or new cropping system like trees for furnishing.

PS4

This production system will remain the same or decrease. This production system use lots of labourers. Worker wage will not decrease. So grain farms do not choose to produce more vegetables and it will be more and more difficult in this production system to hire workers. Excepted if landowners work on their land, they will not be able to hire more workers. However, a price increase could change this observation.

PS5

Milk production attracts more and more farmers. Therefore, on one hand the poorest middle farm owners want to buy more cows. However they need money. They have to wait till their heifers become adult. Thus in three years, we think that the quantity of dairy farms could increase. On the other hand, just few rich middle farms are interested by milk production. Therefore in two years they may have one more cow.

PS6

It is difficult to analyse the evolution of this production system. This production system is very interesting, as we have shown before. Farm income is higher than the others. However, some years, vegetable price can be very low. And in such a case, farm income decrease. Farmers have lots of difficulties to pay farm rents. Nevertheless, in average, we can think that their number will remain the same. After a year during which prices would be high, there would be more farms practising this production system and in the opposite case there would be less.

PS7

This production system allows farmers to just have rice and wheat. We have seen that these farms are not suitable if farmers don't have another activity. However rents seem to be too high. Indeed for four years farmers have not been able to pay rents. They have discussed with owners to change contracts. Nevertheless in future, this type of production system will remain the same. We could see three different observations:

- Farmers who will stop their activity because they are strangle by rents.
- Farmers of this production system who will choose to rent more lands. They will hope to earn more money.
- Farmers of production system 8 who will choose to rent more land and to stop to be workers.

PS8

We have discussed about the fact that some farmers are going to change of production system and will belong to the previous. So we can think that this production system will decrease. However, some workers will achieve to rent some lands and will replace the others farmers.

PS9

Living conditions of these farmers are really hard. Most of them hope to stop being workers. However, just few of them will achieve this goal. Workers with one she-buffalo will be able to rent some lands, and workers with goats will stay labourers. For this production system we can hope they will be able to buy a she-buffalo. Regarding permanent workers their production system will disappear, their living conditions being so hard. In future, workers will come from other cities or blocks like in some places in Ekangar Sarai block.

PS10

If landscape does not change this production system will disappear. It is more and more difficult to find spontaneous fodder during rainy and winter seasons. Moreover, as we have seen during the economic analysis, the income decreases because farmers ask them less and less in order to fertilise their plots.

We have tried to project each production system in future. Now we will argue about different observations and issue in the block and how we can solve it.

Share water

Water is one of a driving force for crop growth. Therefore, there have always been some discrepancies. A better distribution could improve farmers daily.

Inequality in water repartition

As we have noticed before, access to water is unequal. Rich farmers have minimum 3 borings and small farmers none. Landless have to rent water to big farmers. However big farmers are able to limit or block the access in function of relation. Big farmers use water as a means of pressure. If one farmer does not have good relation with the owners of a boring, he cannot irrigate his plots. During rainy season small farmers can use the water present in the canals. There are no rules and no planning to use this water. Government have to help small farmers to develop irrigation facilities. Irrigation allows these small farmers to improve their yields and become more independent. Their living conditions will be also improved.

Work in progress

In 2014, in west part of the block government has created canals. These canals will be connected to the Phalgu River. This allows increasing access to water. However, works have been stopped. It seems that some farmers disturbed the progress of the work done. Government has to follow this idea and develop other project like this. Small farmers will are able to draw water of this canal during rainy season and the beginning of winter season[39]. However there is still a problem during the end of winter season and the summer season.

Organising a water sharing

To solve water issues during the end of winter season and summer season, government can create borings (with a pump) shared by small farmers. Government hire villagers to organise water distribution and planning. This allows creating work for villagers and improves access to water. Small farmers have to pay to use the water but prices are lower than big farmer prices. This allows paying villagers salaries. It is also possible to help small farmers to create a group to finance a project to implement borings. After boring (with pump) creation farmers do not need to pay water. They manage themselves water distribution.

Land reform can help landless to have lands

Access to the water is not the only problem. Another huge issue is the access to land. Without land farmers cannot grow crops.

Lands to absent owners

We have seen in the agrarian history part that some landowners have left rural areas to live in other states or other countries. Nevertheless they have kept their lands. They rent lands to farmers who do not have. In exchange they receive rents. A family member stayed in the native village is in charge to collect these rents. This member can be a brother or a nephew. Owners have another work. Even if it is difficult to evaluate the share of rents in the total income we can say that an owner who rent 7 bighas of land earns around 45 000Rs. This income is equivalent to the price of a fly between Mumbai and Patna for a family or a fly between English speaking countries and India for one people. On first hand for people living in English speaking countries, we imagine that this income is negligible in comparison with their total income. On second hand, for people living in other states, observation can be different. However, although the share in the total income is lower, this is only an additional income.

Farmers need two bighas to survive

During field work, one of questions asked to farmers was: “How many bighas (0.25ha) do you need to raise your family”? Answers were various. We can split big and small farmers or

[39] We could not find more information about the construction of these canals.

landless. On one hand, big farmers have said “we have difficulty to live with our lands”. On the other hand, small farmers have answered “with 2 bighas (0,5ha) without rents I can feed my family”. These two answers are contrasted but understandable. Big farmers do not have same needs than small farmers. Small farmers just want have enough food for living. Big farmers look for a standard of life. Moreover, if we look the graph of the income (graph 21), we see that above 0.25ha per worker all the production systems are above the survival threshold. Therefore we take 2 bighas as limit to survive.

A land reform?

If all farmers needs 2 bighas in order to survive and big absent owners (people who live in other states or other countries) do not need farm income to live (except for pay a fly ticket per year), an arrangement should be possible. Government has to reorganize ownership of land. Government can develop some act in order to buy lands of absent owner who live in other states or other countries. These lands could be reallocated to small farmers and landless.

If a land reform raises too many issues, government can only change its policy. They can determine fixed rent less expensive than today. We have seen that nowadays it is more and more difficult to pay rents. The yields are not been those expected and contracts have to be changed. This emphasizes that rent are too high for tenants. If government determines amount of rents, this allows tenants to save more money. If owners want to earn more money they could sell their lands and government could buy lands.

If government wants to save money they could create contracts with tenants. These tenants could pay a rent cheaper than before, for example 150kg of paddy for a fixed number of years. This paddy could be used in the public distribution system.

A work force seems abundant

Now we will raise another debate. During our study, we have heard many times there is a shortage of workers in the area.

In reality this observation is noticed by big landowners. Indeed, they hire lots of workers because they do not work on their lands (they want to keep their status). We have seen that between 1980 and 2010 lots of workers left Bihar. Therefore this suggests that there are fewer workers in Bihar. It is certainly true and it could be more difficult to negotiate wages for landowners. However we have seen lots of people out of work. They spend all their time in villages. A part of these farmers cannot find a farm work, the other part do not want to do farm work. The low wages led to the emergence of this second category of people. Indeed landowners who do not work on their lands cannot pay high wage if they want to do some benefit. So workers do not want to work and be exploited.

To sum up, we have seen that the shortage of workers comes from three sources: firstly the two migrations, secondly landowners who do not want to work (status question) and thirdly landless who do not want to work on farm (wage questions). There are lots of workers available, nevertheless level of wage and social standing hide the reality.

Good farmers destined to poverty

Some farmers think that their condition is worse than Indian beggars. This observation should be put in perspective. It is not our subject but the living condition of beggars is very bad in India. They live in shanty house and are obliged to beg to survive. Even if we cannot compare the two

situations, what is annoying is this remark has be done by farmers who have at least 7 bighas (1.75ha) and who do not work on their lands (they hire daily workers). Of course farmer conditions are not good but without doing any farm work these farmers can live. Moreover, conditions of most of other villagers are worse.

In order to expose their reasoning farmers has distinguished two types of farmers: the good farmers and the bad farmers. However what is a good farmer? In Bihar, a good farmer is person who has land even if he does not farm work. These farmers take part in meetings to develop the block, receive help of agricultural office. Nevertheless why are they better than the other because they have land? Today if we want to develop the study area we have to take into account small farmers and workers as well. We cannot qualify them as bad farmers. We have discussed with them and some of them know more things about agriculture than landowners, because they cultivate themselves lands. They are interested and they need help as much as or more than landowners.

Some ideas allow developing agriculture

In the study area, government has developed good actions to help farmers. In this part we will only discuss about the ideas and not the means of implementation.

Government have created Primary Agriculture Cooperative Societies. These PACS allow farmers to have loan, subsidies and some advices. Moreover PACS help farmers to sell their paddy. Maybe government can create other cooperative which group small farmers in order to increase their influence in bargaining. Moreover government have created the agricultural office. It allows developing agriculture and organising it in the block.

As we have seen before government also help to create a cold store, canals and new roads. All these actions have a positive impact on the development of Ekangar Sarai block. Government have to follow these actions and try to improve them. They can have a key role like NGOs. However as we have seen, they have to take care of small farmers and landless. Today these farmers do not want to hear of development because every time they have been cheated. They have no confidence in NGOs and government. Government and NGOs have to do some meeting in the part of village where landless and small farmers live. They have to concern them. This have to change if we want to progress with all farmers.

Upgrading agriculture to make it more attractive

We have seen lots of people (landowners or landless) have left their native villages to find a work. Even if this phenomenon decreases, government has to do something in order to prevent a new exodus rural. A solution could be to revaluate the agriculture.

Goal: enhancing agriculture

In order to enhance agriculture we can act on different levers. The first lever could be the improvement of agricultural wages. In order to achieve this goal, on one hand government could fix a minimum wage for workers. Farm works being difficult, this salary should be higher than salaries given by factories. Moreover women's wages are still lower than men's wages. Government could play a role in order to increase their wages. On the other hand, government could help landowners to improve their income. For example, although market prices of products are higher than in other countries, government could increase them. At least, they could try to stabilise them. Indeed, vegetable prices are very changeable from one year to the

next. Another solution could be the development of roads. This allows opening the area to new markets. This could lead to an increase of demand and prices could increase as well. Opportunities have to be provided for each social group (landless, landowners, rich, poor…). If people are aware that their future is not block and they can change it they could be interested in this sector. For example, we could give some lands to landless or a better access to water, etc. It is also important to show, and it is the more difficult, that this sector could seem to be equalitarian. That means there will be no social discriminations (same market and prices for each farmer). If we want to improve the image of agriculture, we have to work upstream with children and their education.

Develop the education

Work on education allows changing children's point of view. Children represent future and we need to show that agriculture could improve their life. We must create specialised school in agriculture and focus lessons on agriculture in village school (after these schools very few people follow their study). Moreover it allows teaching new practises. Then farmers will be able to bargain with market and to be more independent. Today, they depend on big farmers who know laws and rights. Moreover some of them will be able to create some small cooperative or business which will develop agriculture sector and new market. Who can know the issues better than people who come from landless family?

Develop some sector

Last but not least point for this part is the development of sector. We have to try new opportunities for farmers, which can create work and develop the study area. These sectors could be the development of food processing or direct sale. This requires lots of funding and a study of the impact on the environment but this can improve the supply and create new opportunity.

Fight the corruption

One of the more important issues in the Ekangar Sarai block is the corruption. Corruption is everywhere. Farmers who want to sell their paddy to the PACS have to be very close of the head. The ones who want to accede to the PACS have to be able to make a contribution for the head. Just few farmers can get government subsidies because they know employees who work in the agricultural office. This agricultural office gives free seeds of moong bean to rich farmers. This corruption blocks the development of the area. The upward social mobility is blocked. Small farmers and landless have no advantages and cannot develop their farm activity.

If government want to develop the block, fight against corruption should be one of its first fights. They have to change rules of PACS election, elect new members of agricultural office. Without it, all reforms could not be maintained. Moreover they have to include more scheduled castes in the organisations even if there are already some places reserved for scheduled castes in PACS.

Conclusion

We have seen that farm diversity result from the landscape, the history and the social organisation. The green and the white revolution have changed and are still changing the agriculture. However types of farm are closely related to access to water and access to lands. Contrary to other blocks across India, fewer lands were redistributed in the context of the abolition of zamindari system. Green revolution allows big landowners to intensify their production and mechanise their systems. Furthermore, they improved their access to water which has increased the gap with the other farmers. They hired fewer labourers, who were forced to migrate in other states to find a work. Simultaneously, landowners, who looked for better living conditions, went to cities and gave their lands in tenancy.

For twenty years, tenants and small landowners have tried to intensify their production with their means. They have chosen to grow more vegetables. They improve their wealth thanks to an increasing of working time. However, all the areas are not suitable for this production system and some farmers have not been able to intensify their production.

The green revolution and the installation of Sudha dairy cooperative have given to farmers new perspectives. Some landowners have chosen to develop dairy production and intensify their production system. Landless and tenants have started to sell their milk to this dairy cooperative. Nevertheless white revolution is recent, and farmers have to improve their productivity. Moreover tenants have not been able to develop their dairy production because they have to produce grain to pay their land rental and they have not the capabilities to keep or purchase more cows or she-buffalo.

In the future, lots of works have to be done in order to divide wealth equitably between all inhabitants of the block and improve the image of agriculture. Reaching this goal allows helping landless and small farmers and stopping migrations of these social classes towards cities and other states. Even if all these findings must be proved by a study, such actions should improve the Indian economy balance.

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Appendix

Content

Appendix A: Reference value

Name	Quantity	Price
100 INR = 1.57$ = 1.41€		
Lands		
Purchase	1ha	64 000 000 INR
Rent (patta)	1ha	480 000 INR - 800 000INR
Rent (chaurra)	1ha	25 600 kg/rice
Taxes	1ha	150-225 INR
Fertilisers		
Manure	50kg	300 INR
DAP (di-amonium - phosphate)	50kg	1 250 INR
Urea	50kg	320 INR
Sulforus	50kg	590 INR
potash	50kg	900 INR
Zinc	1kg	50 INR
Bromine	1kg	50 INR
Irrigation		
Rented water (diesel pump)	1ha	2 000 INR
Rented water (electric pump)	1 hour	70 INR
flexible pipe	1 feet	4 INR
Rigid pipe	1 feet	75 INR
Equipment		
Tractor	1	600 000 INR
Plow	1	50 000 INR
Thresher (rice mustard	1	7 000 INR
Thresher (lentils, gram	1	15 000 INR
Seeder	1	100 000 INR
Tiller	1	200 000 INR
Windmill	1	3 000 INR
Electric pump (5Hp)	1	20 000 INR
Diesel pump (5Hp)	1	25 000 INR
Boring	1	80 000 INR
protection of boring	1	50 000 INR
Grass machine	1	10 000 INR
Shovel	1	150 INR
Billhook	1	150 INR
Beak	1	300 INR
Basket	1	100 INR

Retal equiment		
Tractor	1ha	2 800 INR
Seeder	1ha	2 400 INR
Thresher	50kg	5 kg
Combine machine (harvester)	1ha	1 000 INR
Grainmill	1kg	2 INR
Seeds		
Paddy	1kg	250 INR in average
Wheat	1kg	40 INR in average
Maize	1kg	85 INR
Oilseeds	1kg	200 INR
Lentil	1kg	75 INR
Gram	1kg	100 INR
Grass pea	1kg	50 INR
Moong bean	1kg	80 INR
Pigeon pea	1kg	120 INR
Fodder (clover)	1kg	150 INR
Fodder (millet)	1kg	50 INR
Sesa tree	1kg	100 INR
Potatoe	1kg	20 INR
Cauliflour	1kg	40 000 INR
Tomato	1kg	20 000 INR
Bringel	1kg	11 000 INR
Pumpkin	1kg	1 000 INR
Lady finger	1kg	500 INR
Bean	1kg	1 000 INR
Onion	1kg	2 000 INR
Phytosanitary product		
Pesticide	1L	400 INR
Herbicide	1L	3 000 INR
Animal food		
Concentrate Sudha	1kg	18 INR
Concentrate (flour)	1kg	17 INR
Mineral	1kg	100 INR
Mustard press cake	1kg	17 INR
Wheat straw	1kg	1 INR
Paddy straw	1kg	1,2 INR
Fish feed	1kg	40 INR

Animal care		
Insemination	1	150 INR
Animal purchasing		
Cow (Sahival)	1	25 000 - 35 000 INR
Foreigner cross-breed	1	50 000-60 000 INR
She-buffalo	1	25 000-45 000 INR
Goats	1	3 500 INR
Fry	1kg	350 INR
Chicks	1	15-25 INR
Products sold to a middleman		
Paddy	1kg	13-15 INR
Paddy PACS	1kg	17 INR
Wheat	1kg	12-14 INR
Maize	1kg	11-13 INR
Oilseeds	1kg	30-40 INR
Lentil	1kg	50-60 INR
Gram	1kg	40-50 INR
Grass pea	1kg	20-25 INR
Moong bean	1kg	65 INR
Pigeon pea	1kg	50-60 INR
Sesa tree	1kg	25 000 INR
Potatoe	1kg	5-9 INR
Cauliflour	1kg	5-10 INR
Tomato	1kg	4-7 INR
Bringel	1kg	7-12 INR
Pumpkin	1kg	2.5-5 INR
Lady finger	1kg	2-7 INR
Bean	1kg	2-7 INR
Onion	1kg	15-25 INR
Mango	1kg	20 INR
Banana	12	30-50 INR
Product derived of livestock		
Cow milk (Sudha)	1L	23 INR
Cow milk	1L	31 INR
She-buffalo milk (Sudha)	1L	28 INR
She-buffalo milk	1L	35 INR
Cow calve (8 mois)	1	7 000 INR
Cow calve (2 ans)	1	15 000 INR
Buffalo calve (2 ans)	1	20 000 INR
Cooking dung cake	4	1 INR
Chicken meat	1kg	90-120 INR
Goat meat	1kg	300 INR
sheep meat	1kg	400 INR
Fish meat	1kg	150-300 INR

Appendi B : Schemes

Figure 59: Historical timeline of Ekangar Sarai block

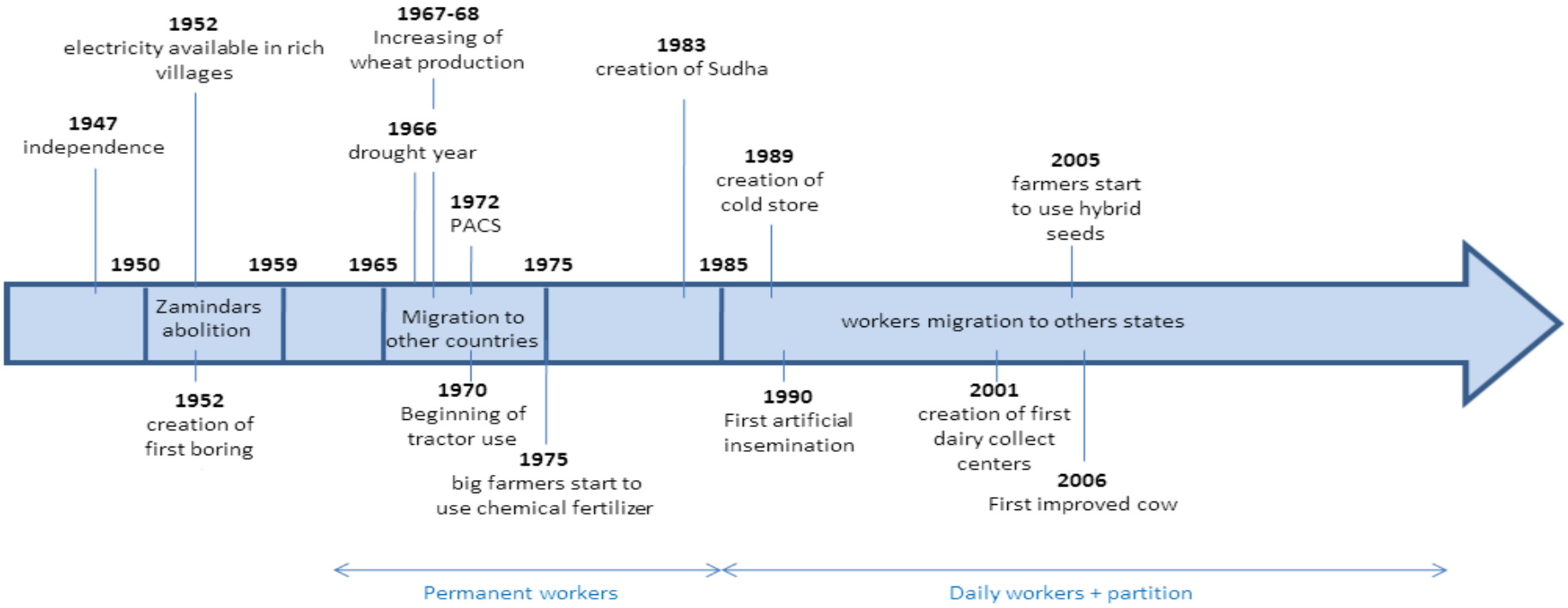


Figure 60: How to manage a cow or a she-buffalo

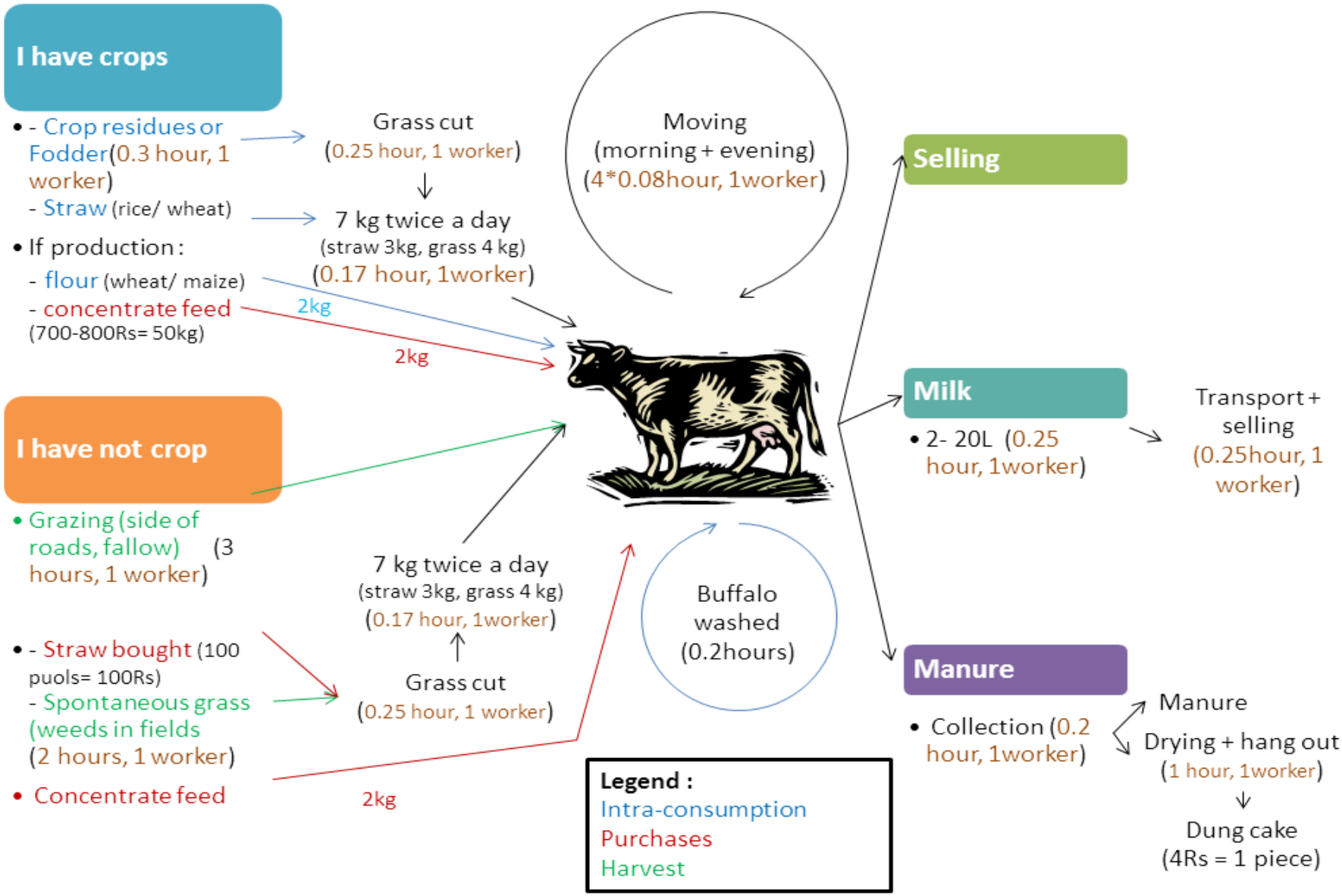
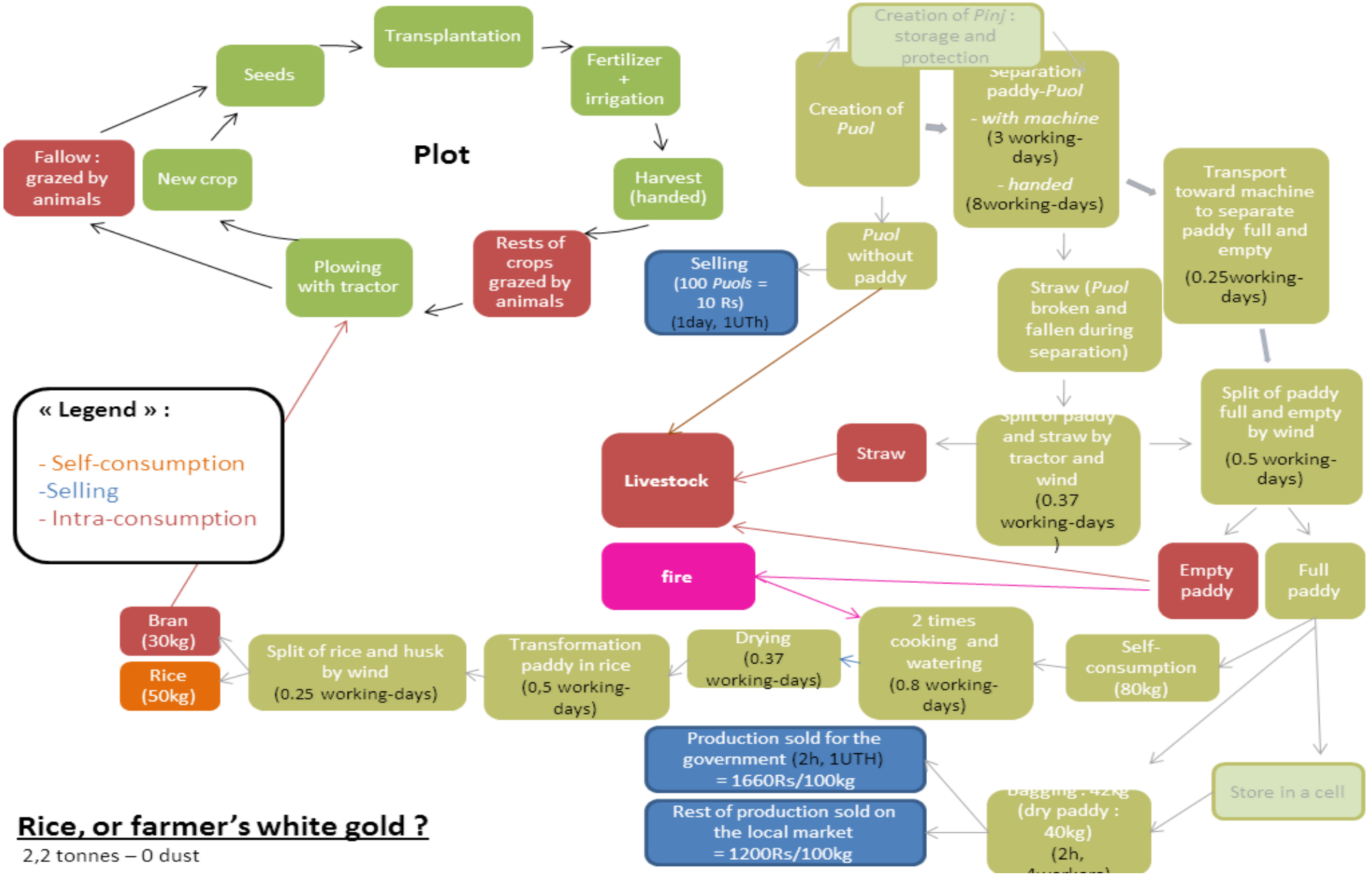


Figure 61: Paddy management



Rice, or farmer's white gold ?

2,2 tonnes – 0 dust

Appendix C: Crop systems

Table 6: Rotation Paddy/grass pea/ fallow

		Quantity (kg) /ha	Rs/ha	January		February		March		April		May		June		July		August		September		October		November		December	
Paddy(C1)				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Products		48 q	74880																								
Co-products		8000 puols	8800																								
Nursery	Plowing	oil = 1L	56										0.25														
	Irrigation	56m³	200										1		1	Flooding											
	Seeding	20 kg	5000											0.05	Hybrid seec												
	Weeding														3												
	Fertilization													0.1	0.1	Urea											
	Pesticide													50% DAP	0.1												
	Harvesting													+50% Urea		4											
Seeding preparation	Plowing	6 times (20L)	1120												1.5	Tractor											
	Soil working															2	Division of the plot to improve irrigations										
	Irrigation	320m³	2000												1	before seeding											
	Transplantation															40	Transplantation by women										
Weeding		1.2 L	3600														15	Manualy + Weed	25	Manualy							
Irrigation		1280m³	8000															1	1		1		1				
Fertilization		600 kg	7968													2		2 Urea									
Pesticides		1.6 L	640													33% DAP			2	against stemborar	2	against har					
Harvest	Cuting															+33% Urea								35	Creation of puols		
	Creation of puol															+33% Macroelements								12	Creation of pinj		
	Threshing	oil = 19L	1075		32																						
	Bagging + selling						4																				
Total paddy				C1	GP	83700 Rs				IC		29700 Rs					AV	54000 Rs					Work	189 Days			
Grass peas (C2)																											
Products		8 q	17600																								
Co-products		1200 kg	2160																								
Seeding preparation	Plowing																										
	Soil working																										
	Irrigation before seeding																										
	Transplantati	80 kg	4000																					1	Seeding in the rice		
Weeding																											
Irrigation																											
Fertilization																											
Pesticides																											
Harvest	Cuting								20	Manually																	
	Creation of bundel								7	Transport to the house																	
	Threshing	Oil = 16L	560						20																		
	Bagging + selling									12.3																	
Total grass peas				C2	GP	19800 Rs				IC		4 600 Rs					AV	15200 Rs					Work	60 Days			
Total C1+C2					**GP**	**103500**		**Rs**		**IC**		**34300**	**Rs**				**AV**	**69200**		**Rs**			**Work**	**249**		**Days**	

Table 7: Rotation Paddy/lentil/fallow

		Quantity (kg) /ha	Rs/ha	January		February		March		April		May		June		July		August		September		October		November		December	
Paddy (C1)				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Products		48q	74880																								
Co-products		8000 puols	8800																								
Nursery	Plowing	oil = 1L	56										0.3														
	Irrigation	56m³	200										0.9		1	Flouding											
	Seeding	20kg	5000											0.05	Hybrid seec												
	Weeding														3												
	Fertilization													0.01	0	Urea											
	Pesticide													50% DAP	4												
	Harvesting													+50% Urea		4											
Seeding preparation	Plowing	6 times (20L)	1120												1.5	Tractor											
	Soil working															2	Division of the plot to improve irrigations										
	Irrigation	320m³	2000												1												
	Transplantation															40	Transplantation by women										
Weeding		1.2L	3600														15	Manualy + Weed killer	25	Manualy							
Irrigation		1280m³	8000															1	1		1		1				
Fertilization		600kg	7968													2	33% DAP	2 Urea									
Pesticides		1.6L	640														+33% Urea		2	against stemborar	2	against har					
Harvest	Cuting																+33% Macroelements							35	Creation of puols		
	Creation of puol																							12	Creation of pinj		
	Threshing	oil = 19L	1075.2		32																						
	Bagging + selling						4																				
Total paddy				C1	GP	83700	Rs		IC	29700	Rs						GAV	54000	Rs			Work	189	Days			
Lentils (C2)																											
Products		12,8q	61440																								
Co-products		12q	2160																								
Seeding preparation	Plowing	6 times (20L)	1120																					1.5			
	Soil working																							2			
	Irrigation before seeding																										
	Transplantati	Sweet 80kg	6000																					0.8			
Weeding																											
Irrigation																											
Fertilization		DAP 120kg	3000																					2 DAP			
Pesticides		2L	800		2	against ghangara																				2	
Harvest	Cuting							20	Manually																		
	Creation of bundel							7	Transport to the house																		
	Threshing	oil = 16L	896						20																		
	Bagging + selling											12	drying														
Total lentils				C2	GP	63600	Rs		IC	11800	Rs						GAV	51800	Rs			Work	70	Days			
Total C1+C2					**GP**	**147300**	**Rs**		**IC**	**41500**	**Rs**						**GAV**	**105800**	**Rs**			**Work**	**259**	**Days**			

Table 8: Rotation Paddy/gram/fallow

	Quantity (kg) /ha	Rs/ha	January		February		March		April		May		June		July		August		September		October		November		December	
Paddy (C1)			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Products	48q	74880																								
Co-products	8000 puols	8800																								
Total paddy			C1	GP	83700		Rs		IC	29700		Rs				GAV	54000		Rs				Work	189	Days		
Grams (C2)																										
Products	11,2q	44800																								
Co-products	12q	2160																								
Total grams			C2	GP	47 000		Rs		IC	13 700		Rs				GAV	33300		Rs				Work	68	Days		
Total C1+C2				**GP**	**130700**		**Rs**		**IC**	**43 400**		**Rs**				**GAV**	**87300**		**Rs**				**Work**	**257**	**Days**		

Table 9: Rotation Paddy/wheat/fallow

		Quantity (kg) /ha	Rs/ha	January		February		March		April		May		June		July		August		September		October		November		December	
Paddy (C1)				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Products		48q	74880																								
Co-products		8000 puols	8800																								
Nursery	Plowing	oil = 1L	56										0.3														
	Irrigation	56m³	200										0.9		1	Flouding											
	Seeding	20kg	5000											0.05	Hybrid see												
	Weeding														3												
	Fertilization													0.01	0	Urea											
	Pesticide													50% DAP	4												
	Harvesting													+50% Urea		4											
Seeding preparation	Plowing	6 times (20L)	1120												1.5	Tractor											
	Soil working															2	Division of the plot to improve irrigations										
	Irrigation	320m³	2000												1												
	Transplantation															40	Transplantation by women										
Weeding		1.2L	3600														15	Manualy + Weed killer	25	Manualy							
Irrigation		1280m³	8000															1			1		1				
Fertilization		600kg	7968													2	33% DAP	2 Urea									
Pesticides		1.6L	640														+33% Urea		2	against stemborar	2	against ha					
Harvest	Cuting																+33% Macroelements							35	Creation of puols		
	Creation of puol																							12	Creation of pinj		
	Threshing	oil = 19L	1075.2		32																						
	Bagging + selling						4																				
Total paddy				C1	GP	83700	Rs			IC	29700	Rs					GAV	54000	Rs			Work	189	days			
Wheat (C2)																											
Products		33.6q	47040																								
Co-products		16.8q	3024																								
Seeding preparation	Plowing	6 times (20L)	1120																							1.5	
	Soil working																									2	
	Irrigation bef	560m³	2000																							1	
	Transplantat	160kg	6400																							0.8	
Weeding		1.2L	3600																							3	(Weed killer)
Irrigation		1680m³	6000																								
Fertilization		400kg	5176																							2	50 % DAP
Pesticides		0.8L	320	1	1			1																			+50% Urea
Harvest	Cuting			2	Urea					17	50% harvester																
	Creation of bundel			2						12																	
	Threshing	50% harvester (2000Rs) + 50% tressor	5880							3																	
	Bagging + selling													4													
Total lentils				C2	GP	50 100	Rs			IC	30 500	Rs					GAV	19600	Rs			Work	52	Days			
Total C1+C2					**GP**	**133800**	**Rs**			**IC**	**60200**	**Rs**					**GAV**	**73600**	**Rs**			**Wo**	**241**	**Days**			

Table 10: Rotation Paddy/wheat/fallow (small farmers)

		Quantity (kg) /ha	Rs/ha	January		February		March		April		May		June		July		August		September		October		November		December	
Paddy (C1)				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Products		32q	44800																								
Co-products		8000 puols	8800																								
Nursery	Plowing	oil = 1L	140										0.3														
	Irrigation	56m³	200										0.9		1	Flouding											
	Seeding	20kg	5000											0.05	Hybrid see												
	Weeding														3												
	Fertilization													0.01	0	Urea											
	Pesticide													50% DAP	4												
	Harvesting													+50% Urea		4											
Seeding preparation	Plowing	6 times (20L)	1120												1.5	Tractor											
	Soil working															2	Division of the plot to improve irrigations										
	Irrigation	320m³	2000												1												
	Transplantation															40	Transplantation by women										
Weeding																	25	Manualy	25	Manualy							
Irrigation		960m³	6000															1				1		1			
Fertilization		440kg	5048													2	50% DAP	2 Urea									
Pesticides		1L	450														+50% Urea		2	against stemborar							
Harvest	Cuting																							35	Creation of puols		
	Creation of puol																							12	Creation of pinj		
	Threshing	oil = 19L	1075		58																						
	Bagging + selling						4																				
Total paddy				C1	GP	53600	Rs			IC	21800	Rs					GAV	31800	Rs				Work	225	days		
Wheat (C2)																											
Products		21,6q	30200																								
Co-products		21,6q	3900																								
Seeding preparation	Plowing	6 times (20L)	2800																							1.5	
	Soil working																									2	
	Irrigation be	560m³	2000																							1	
	Transplantat	160kg	6400																							0.8	
Weeding																											
Irrigation		1120m³	4000	1																							
Fertilization		320	3536	2	Urea																					2	50% DAP
Pesticides		0.8	320	2				1																			50% Urea
Harvest	Cuting									34	manualy																
	Creation of bundel									12																	
	Threshing	100% manualy	3780							3																	
	Bagging + selling													2													
Total lentils				C2	GP	34 100	Rs			IC	22 800	Rs					GAV	11 300	Rs				Work	66	Days		
Total C1+C2					**GP**	**87700**	**Rs**			**IC**	**44600**	**Rs**					**GAV**	**43100**	**Rs**				**Wo**	**291**	**Days**		

Table 11 Rotation Paddy/lentil/moong bean

		Quantity (kg) /ha	Rs/ha	January		February		March		April		May		June		July		August		September		October		November		December	
Paddy (C1)				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Products		48q	74880																								
Co-products		8000 puols	8800																								
Nursery	Plowing	oil = 1L	56										0.25														
	Irrigation	56m³	200										0.88		1	Flouding											
	Seeding	20kg	5000											0.05	Hybrid seeds												
	Weeding														3												
	Fertilization													0.01	0.01	Urea											
	Pesticide													50% DAP	4												
	Harvesting													+50% Urea		4											
Seeding preparation	Plowing	6 times (20L)	1120												1.5	Tractor											
	Soil working															2	Division of the plot to improve irrigations										
	Irrigation	320m³	2000												1												
	Transplantation															40	Transplantation by women										
Weeding		1.2L	3600														15	Manualy + Weed killer	25	Manualy							
Irrigation		1280m³	8000															1			1		1				
Fertilization		600kg	7968													2	33% DAP	2 Urea									
Pesticides		1.6L	640														+33% Urea		2	against stembora	2	against harda					
Harvest	Cuting																+33% Macroelements							35	Creation of puols		
	Creation of puol																							12	Creation of pinj		
	Threshing	oil = 19L	1075		32																						
	Bagging + selling						4																				
Total paddy				C1	GP	83700	Rs		IC	29700	Rs						GAV	54000	Rs				Work	189	days		
Lentils (C2)																											
Products		12,8q	61440																								
Co-products		12q	2160																								
Seeding preparation	Plowing	6 times (20L)	1120																						1.5		
	Soil working																								2		
	Irrigation before seeding																										
	Transplantati	Sweet 80kg	6000																						0.75		
Weeding																											
Irrigation																											
Fertilization		DAP 120kg	3000																						2 DAP		
Pesticides		2L	800		2	against ghangara																				2	
Harvest	Cuting							20	Manually																		
	Creation of bundel							7	Transport to the house																		
	Threshing	oil = 16L	896						20																		
	Bagging + selling											12	0														
Total lentils				C2	GP	63600	Rs		IC	11800	Rs						GAV	51800	Rs				Work	70	Days		

Moong bean (C3)																					
Products		7.2	46800																		
Co-products																					
Seeding preparation	Plowing	6 times (20L)	1120					1.5													
	Soil working							2													
	Irrigation befo	560 m³	2000					1													
	Transplantati	20kg	1600					0.75	during ploing												
Weeding																					
Irrigation		2240m³	8000							1	2	1									
Fertilization		160kg	2560					2	NPK	2	Urea										
Pesticides		2L	800									2									
Harvest	Cuting									17	17	17	3 times								
	Creation of bundel											5									
	Threshing									10	10	10									
	Bagging + selling																				
Total lentils				C2	GP	46 800	Rs	IC	16 100	Rs					GAV	30700	Rs		Work	102 Days	
Total C1+C2 + C3					**GP**	**194 100**	**Rs**	**IC**	**57 600**	**Rs**					**GAV**	**136500**	**Rs**		**Work**	**361**	**Days**

Table 12: Rotation Paddy/potatoe/onion

		Quantity (kg) /ha	Rs/ha	January		February		March		April		May		June		July		August		September		October		November		December	
Paddy (C1)				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Products		48q	74880																								
Co-products		8000 puols	8800																								
Nursery	Plowing	oil = 1L	56										0.3														
	Irrigation	56m³	200										0.9		1	Flouding											
	Seeding	20kg	5000											0.05	Hybrid seeds												
	Weeding														3												
	Fertilization													0.01	0.0125	Urea											
	Pesticide													50% DAP	4												
	Harvesting													+50% Urea		4											
Seeding preparation	Plowing	6 times (20L)	1120												1.5	Tractor											
	Soil working															2	Division of the plot to improve irrigations										
	Irrigation	320m³	2000												1												
	Transplantation															40	Transplantation by women										
Weeding		1.2L	3600														15	Manualy + Weed killer	25	Manualy							
Irrigation		1280m³	8000															1			1		1				
Fertilization		600kg	7968													2	3% DA	2 Urea									
Pesticides		1.6L	640														+33% Urea		2	against stemborar	2	against har					
Harvest	Cuting																+33% Macroelement							35	Creation of puols		
	Creation of puol																							12	Creation of pinj		
	Threshing	oil = 19L	1075		32																						
	Bagging + selling						4																				
Total paddy				C1 GP		83700		Rs		IC		29700	Rs			GAV		54000	Rs			Work 189 days					
Potatoes (C2)																											
Products		240q	120000																								
Co-products																											
Seeding preparation	Plowing	6 times (20L)	1120																					1.5			
	Soil working																							30			
	Irrigation bef	560m³	2000																					1			
	Transplantati	2400kg	48000																					60			
Weeding																										50 (manualy + hoeing)	
Irrigation		2240m³	8000	1	1																				1	1	
Fertilization		1600kg	25888																					2 (50% DAP	(Urea	2 (Urea)	
Pesticides		16L	8000	2	2																				2	2	
Harvest	Cuting					80	Sometimes stock at the cold store																				
	Creation of bundel					3																					
	Threshing																										
	Bagging + selling									2																	
Total Potatoes				C2 GP		120000		Rs		IC		93 000	Rs			GAV		27000	Rs			Work 246 Days					

Onion (C3)																									
Products		156q	202800																						
Co-products																									
Nursery	Plowing																							0.2	
	Irrigation	6 times (0.5L)	112																					0.9	
	Seeding	112m³	400																						0.05
	Weeding	20kg	40000	3		3	Manualy																		
	Fertilization																							0	0.01
	Pesticide			0.1																				50% DAP	
	Harvesting						4	Men																+50% potasse	
Seeding preparation	Plowing					1.5																			
	Soil working	6 times (20L)	1120				30																		
	ion before seeding						1.125																		
	Seeding	560m³	2000				40																		
Weeding									45	Maualy	45														
Irrigation									2	2	1.1														
Fertilization		3920m³	14000				2 (50% DAP + 50% Potasse)		2 (Ur	2 (Urea)															
Pesticides		1840kg	34240					2	2	2															
Harvest	Cuting	4L	2000										80												
	Transport & Creation of puol												3												
	Threshing																								
	Bagging + selling																2								
Onion (C3)				C2	GP		202 800	Rs		IC	93 900		Rs				GAV	108900	Rs			Work	277 Days		
Total C1+C2 + C3					**GP**		**406 500**	**Rs**		**IC**	**216 600**			**Rs**			**GA**	**189 900**	**Rs**			**Wo**	**712**	**Days**	

Table 13: Rotation Paddy/Potatoe/Maize

		Quantity (kg) /ha	Rs/ha	January		February		March		April		May		June		July		August		September		October		November		December	
Paddy (C1)				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Products		48q	74880																								
Co-products		8000 puols	8800																								
Nursery	Plowing	oil = 1L	56										0.25														
	Irrigation	56m³	200										0.88		1	Flouding											
	Seeding	20kg	5000											0.05	Hybrid seed												
	Weeding														3												
	Fertilization													0.01	0.01	Urea											
	Pesticide													50% DAP	4												
	Harvesting													+50% Urea		4											
Seeding preparation	Plowing	6 times (20L)	1120												1.5	Tractor											
	Soil working															2	Division of the plot to improve irrigations										
	Irrigation	320m³	2000												1												
	Transplantation															40	Transplantation by women										
Weeding		1.2L	3600														15	Manualy + Weed killer	25	Manualy							
Irrigation		1280m³	8000															1			1		1				
Fertilization		600kg	7968													2	33% DAP	2 Urea									
Pesticides		1.6L	640														+33% Urea		2	against stemborar	2	against har					
Harvest	Cuting																+33% Macroelements							35	Creation of puols		
	Creation of puol																							12	Creation of pinj		
	Threshing	oil = 19L	1075.2		32																						
	Bagging + selling						4																				
Total paddy				C1 GP 83700 Rs IC 29700 Rs GAV 54000 Rs Work 189 days																							
Potatoes (C2)																											
Products		240q	120000																								
Co-products																											
Seeding preparation	Plowing	6 times (20L)	1120																					1.5			
	Soil working																							30			
	Irrigation bef	560m³	2000																					1			
	Transplantati	2400kg	48000																					60			
Weeding																										50 (manualy + hoeing)	
Irrigation		2240m³	8000	1	1																					1	1
Fertilization		1600kg	25888																					2 (50% DAP + 50% Potasse)		2 (Urea)	2 (Urea)
Pesticides		16L	8000	2	2																					2	2
Harvest	Cuting					80	Sometimes stock at the cold store																				
	Creation of bundel					3																					
	Threshing																										
	Bagging + selling									2																	
Total Potatoes				C2 GP 120000 Rs IC 93 000 Rs GAV 27000 Rs Work 246 Days																							

Maize (C3)																									
Products		56q	72800																						
Co-products																									
Seeding preparation	Plowing	6 times (20L)	1120			1.5																			
	Soil working					2																			
	Irrigation bef	560m³	2000			1																			
	Transplantati	24g	2040			0.75	Able to be seed before harvestingof potatoes																		
Weeding																									
Irrigation		2240m³	8000					1		1	1	1													
Fertilization		440kg	5048			2	50% DAP	2	Urea																
Pesticides		1.6L	640					2	Against pati		2														
Harvest	Cuting													27											
	Creation of bundel													7											
	Threshing														53										
	Bagging + selling																	2							
Total maize				C2	GP	72 800		Rs		IC	18 900		Rs				GAV	53900		Rs		Work	106 Days		
Total C1+C2 + C3					**GP**	**276 500**		**Rs**		**IC**	**141 600**			**Rs**			**GAV**	**134900**		**Rs**		**Work**	**541**	**Days**	

Table 14: Rotation Paddy/potatoe/vegetable

		Quantity (kg) /ha	Rs/ha	January		February		March		April		May		June		July		August		September		October		November		December	
Paddy (C1)				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Products		48q	74880																								
Co-products		8000 puols	8800																								
Nursery	Plowing	oil = 1L	56										0.3														
	Irrigation	56m³	200										0.9		1	Flouding											
	Seeding	20kg	5000											0.05	Hybrid seec												
	Weeding														3												
	Fertilization													0.01	0	Urea											
	Pesticide													50% DAP	4												
	Harvesting													+50% Urea		4											
Seeding preparation	Plowing	6 times (20L)	1120												1.5	Tractor											
	Soil working															2	Division of the plot to improve irrigations										
	Irrigation	320m³	2000												1												
	Transplantation															40	Transplantation by women										
Weeding		1.2L	3600														15	Manualy + Weed killer	25	Manualy							
Irrigation		1280m³	8000															1			1		1				
Fertilization		600kg	7968													2	33% DAP	2 Urea									
Pesticides		1.6L	640														+33% Urea		2	against stemborar	2	against har					
Harvest	Cuting																+33% Macroelements							35	Creation of puols		
	Creation of puol																							12	Creation of pinj		
	Threshing	oil = 19L	1075.2		32																						
	Bagging + selling						4																				
Total paddy				C1 GP 83700 Rs IC 29700 Rs GAV 54000 Rs Work 189 days																							
Potatoes (C2)																											
Products		240q	120000																								
Co-products																											
Seeding preparation	Plowing	6 times (20L)	1120																					1.5			
	Soil working																							30			
	Irrigation befc	560m³	2000																					1			
	Transplantatic	2400kg	48000																					60			
Weeding																										50 (manualy + hoeing)	
Irrigation		2240m³	8000	1	1																					1	1
Fertilization		1600kg	25888																					2 (50% DAP + 50% Potasse)		2 (Urea)	2 (Urea)
Pesticides		16L	8000	2	2																					2	2
Harvest	Cuting						80	Sometimes stock at the cold store																			
	Creation of bundel						3																				
	Threshing																										
	Bagging + selling										2																
Total Potatoes				C2 GP 120000 Rs IC 93 000 Rs GAV 27000 Rs Work 246 Days																							

Vegetable (C3)																									
Products		210q	105000																						
Co-products																									
Seeding preparation	Plowing	6 times (20L)	1120				1.5																		
	Soil working							60	Ploing manualy to limit the weeds																
	Irrigation befo	560m^3	2000					1																	
	Transplantati	5kg	8983					30																	
Weeding		0	0						40	40															
Irrigation		5600m^3	20000						1	2	2	2	2	1											
Fertilization		280kg	3328					2	75% DAP + 25% urea	2	Urea														
Pesticides		2.8L	1400						2		2	2	2												
Harvest	Cuting									30	30	30	30	30	30										
	Creation of bundel									5	5	5	5	5	5										
	Threshing																								
	Bagging + selling																	2							
Total vgetable				C2	GP	105 000		Rs		IC	36 800		Rs				GAV	68200	Rs			Work	404 Days		
Total C1+C2 + C3					**GP**	**308 700**		**Rs**		**IC**	**159 500**			**Rs**			**GAV**	**149200**	**Rs**			**Wo**	**839**	**Days**	

Table 15: Rotation Paddy/vegetable/vegetable

		Quantity (kg) /ha	INR/ha	January		February		March		April		May		June		July		August		September		October		November		December	
Paddy (C1)				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Products		48q	74880																								
Co-products		8000 puols	8800																								
Nursery	Plowing	oil = 1L	56										0.25														
	Irrigation	56m³	200										0.88		1	Flouding											
	Seeding	20kg	5000											0.05	Hybrid seec												
	Weeding														3												
	Fertilization													0.01	0.01	Urea											
	Pesticide													50% DAP	4												
	Harvesting													+50% Urea		4											
Seeding preparation	Plowing	6 times (20L)	1120												1.5	Tractor											
	Soil working															2	Division of the plot to improve irrigations										
	Irrigation	320m³	2000												1												
	Transplantation															40	Transplantation by women										
Weeding		1.2L	3600														15	Manualy + Weed killer	25	Manualy							
Irrigation		1280m³	8000															1			1		1				
Fertilization		600kg	7968													2	33% DAP	2 Urea									
Pesticides		1.6L	640														+33% Urea		2	against stemborar	2	against harda					
Harvest	Cuting																+33% Macroelements							35	Creation of puols		
	Creation of puol																							12	Creation of pinj		
	Threshing	oil = 19L	1075.2		32																						
	Bagging + selling						4																				
Total paddy				C1 GP 83700 Rs						IC 29700 Rs							GAV 54000 Rs							Work 189 days			
Vegetable (C2)																											
Products		240q	120000																								
Co-products																											
Seeding preparation	Plowing	6 times (20L)	1120																					1.5			
	Soil working																								60	Ploing manualy to	
	Irrigation bef	560m³	2000																						1	limit number of weeds	
	Transplantati	2400kg	48000																						30		
Weeding				40	Manualy + binage																						40
Irrigation		2240m³	8000	1	1																					1	1
Fertilization		1600kg	25888																						2 (75% DAP+ 25%urea)	2 (Urea)	
Pesticides		16L	8000	2	2																						2
Harvest	Cuting			30	30	30	30																				30
	Creation of bundel			5	5	5	5																				5
	Threshing																										
	Bagging + selling									2																	
Total Vegetable				C2 GP 135100 Rs						IC 32 300 Rs							GAV 102800 Rs							Work 364 Days			

Vegetable (C3)																										
Products		210q	105000																							
Co-products																										
Seeding preparation	Plowing	6 times (20L)	1120				1.5																			
	Soil working							60	Ploing manualy to limit the weeds																	
	Irrigation befo	560m³	2000					1																		
	Transplantati	5kg	8983					30																		
Weeding									40	40																
Irrigation		5600m³	20000						1	2	2	2	2	1												
Fertilization		280kg	3328					2	75% DAP + 25% urea	2	Urea															
Pesticides		2.8L	1400						2		2	2	2													
Harvest	Cuting									30	30	30	30	30	30											
	Creation of bundel									5	5	5	5	5	5											
	Threshing																									
	Bagging + selling																	2								
Total vgetable				C2	GP	105 000		Rs		IC	36 800		Rs				GAV	68200	Rs				Work	404 Days		
Total C1+C2 + C3					**GP**	**323 800**			**Rs**	**IC**	**98 800**		**Rs**				**GAV**	**225000**	**Rs**				**Wo**	**957**	**Days**	

Table 16: Rotation Vegetable/vegetable/vegetable

		Quantity (kg) /ha	INR/ha	January		February		March		April		May		June		July		August		September		October		November		December	
Vegetable (C1)				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Products		210q	105000																								
Co-products																											
Seeding preparation	Plowing	6 times (20L)	1120												1.5												
	Soil working	Division of the plot to improve irrigations														60	Ploing manualy to limit the weeds										
	Irrigation	560m³	2000													1											
	Transplantati	5kg	8983													30											
Weeding																		40	40	Manualy + bir							
Irrigation		960m³	6000															1	1		1						
Fertilization		280kg	3328													2 (75% DAP+ 25%urea)		2 (Urea)									
Pesticides		2.8L	1400														2	2	2	2							
Harvest	Cuting																	30	30	30	30	30	30				
	Creation of puol																	5	5	5	5	5	5				
	Threshing																										
	Bagging + selling																										
Total vegetable				C1	GP	105000	Rs			IC	22800	Rs					GAV	82200	Rs				Work	398 days			
Vegetable (C2)																											
Products		240q	120000																								
Co-products																											
Seeding preparation	Plowing	6 times (20L)	1120																					1.5			
	Soil working																								60	0	
	Irrigation bef	560m³	2000																						1		
	Transplantati	2400kg	48000																						30		
Weeding				40	Manualy + binage																						40
Irrigation		2240m³	8000	1	1																					1	1
Fertilization		1600kg	25888																						2 (75% DAP+ 25%urea)	2 (Urea)	
Pesticides		16L	8000	2	2																						2
Harvest	Cuting			30	30	30	30																				30
	Creation of bundel			5	5	5	5																				5
	Threshing																										
	Bagging + selling									2																	
Total Vegetable				C2	GP	135100	Rs			IC	32 300	Rs					GAV	102800	Rs				Work	364 Days			
Vegetable (C3)																											
Products		210q	105000																								
Co-products																											
Seeding preparation	Plowing	6 times (20L)	1120				1.5																				
	Soil working							60	Ploing manualy to limit the weeds																		
	Irrigation bef	560m³	2000					1																			
	Transplantati	5kg	8983					30																			
Weeding									40	40																	
Irrigation		5600m³	20000						1	2	2	2	2	1													
Fertilization		280kg	3328					2	75% DAP + 25% urea	2	Urea																
Pesticides		2.8L	1400						2		2	2	2														
Harvest	Cuting									30	30	30	30	30	30												
	Creation of bundel									5	5	5	5	5	5												
	Threshing																										
	Bagging + selling																	2									
Total vgetable				C2	GP	105 000	Rs			IC	36 800	Rs					GAV	68200	Rs				Work	404 Days			
Total C1+C2 + C3					**GP**	**345 100**	**Rs**			**IC**	**91 900**	**Rs**					**GAV**	**253200**	**Rs**				**Work**	**1166**		**Days**	

Table 17: Rotation Maize/mustard/fallow

Maize (C1)		Quantity (kg) /ha	INR/ha	January 1	2	February 3	4	March 5	6	April 7	8	May 9	10	June 11	12	July 13	14	August 15	16	September 17	18	October 19	20	November 21	22	December 23	24
Products		56q	72800																								
Co-products		0																									
Seeding preparation	Plowing	6 times (20L)	1120												1.5												
	Soil working	Division of the plot to improve irrigations													2												
	Irrigation	560m³	2000												1												
	Transplantati	24kg	2040												0.75												
Weeding		0	0																								
Irrigation		2240m³	8000													1		1	1								
Fertilization		440kg	5048												2 (50%DAP + 50%Urea)		2 (Urea)										
Pesticides		1.6L	640													2			2								
Harvest	Cuting																										
	Transport																										
	Threshing																										
	Bagging + selling																										
Total maize				C1	GP	72800	Rs		IC	18800	Rs						GAV	54000	Rs				Work	105	days		
Mustard (C2)																											
Products		10.4q	36400																								
Co-products		16q	960																								
Seeding preparation	Plowing	oil = 20L	1120																							1.5	
	Soil working																									2	
	Irrigation bef	560m³	2000																							1	
	Transplantati	10kg	2000																							0.75	
Weeding																											
Irrigation		560m³	2000	1																							
Fertilization		400kg	4792	2 (Urea)																						2 (50%DAP + 50%Urea)	
Pesticides		0.8L	320	2																							
Harvest	Cuting						27																				
	Creation of bundel						7																				
	Threshing							130	lanualy																		
	Bagging + selling							2																			
Total mustard				C2	GP	37400	Rs		IC	12 200	Rs						GAV	25200	Rs				Work	175	Days		
Total C1+C2					**GP**	**110 200**	**Rs**		**IC**	**31 000**	**Rs**						**GAV**	**79200**	**Rs**				**Work**	**280**	**Days**		

Table 18: Rotation Pigeon peas

		Quantity (kg) /ha	INR/ha	January		February		March		April		May		June		July		August		September		October		November		December	
Pigeon peas (C1)				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Products		960	48000																								
Co-products		12000	9600																								
Seeding preparation	Plowing	6 times	1120											1.5													
	Soil working													2													
	Irrigation																										
	Transplantati	24	2880											0.75													
Weeding																											
Irrigation																											
Fertilization																											
Pesticides																											
Harvest	Cuting								27																		
	Transport								5																		
	Threshing								40																		
	Bagging + selling																										
Total maize				C1	GP	0	Rs	IC	0	Rs						GAV	0	Rs				Work	0 days				

Table 19: Rotation Teak

		Quantity/ha	Rs/ha	January		February		March		April		May		June		July		August		September		October		November		December	
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Products		1600	800000			GI		800000	Rs			IC		49620	Rs			AV		750380	Rs			Work	97	Days	
Seeding preparation	Plowing	6 times	1120																					1.5			
	Soil working	Preparation of 'trou'																						11			
	ation before see	80	2000																					2			
	Seeding	2000	10000																					11			
Weeding																									20		
Irrigation		6720	24000	2		2		2		2	2	2	2		2										2		2
Fertilization		500	12500																						2 (Urea)		2 (Urea)
Pesticides	Insecticides																										
Harvest	Cuting											21															
	Transport											7															
	Threshing																										
	Bagging + selling																										

Appendix D:

Figure 62: She-buffalo grazing a part of the year

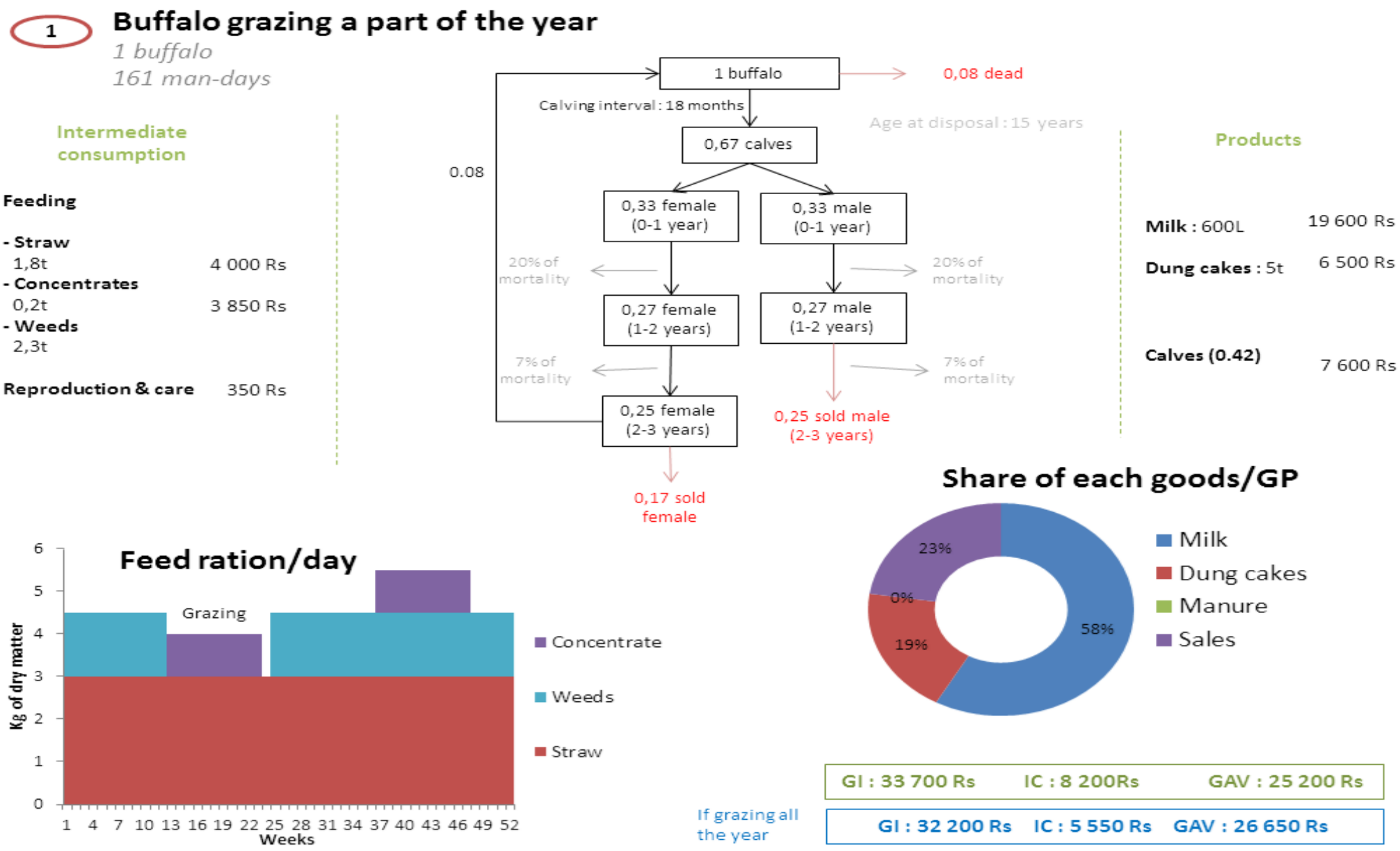


Figure 63: 3 She-buffalo in middle dairy farm

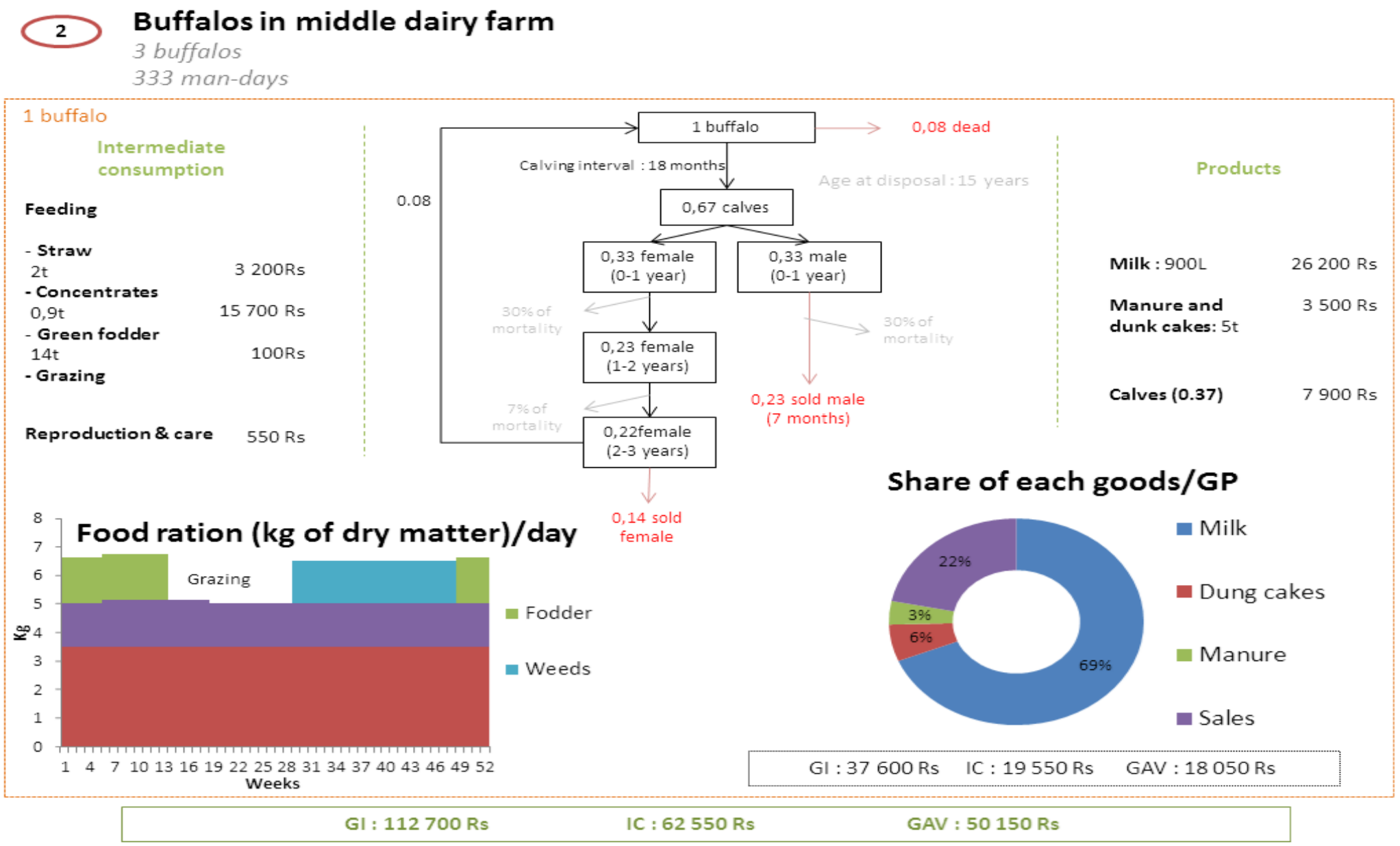


Figure 64: 1 She-buffalo in tie-stalls

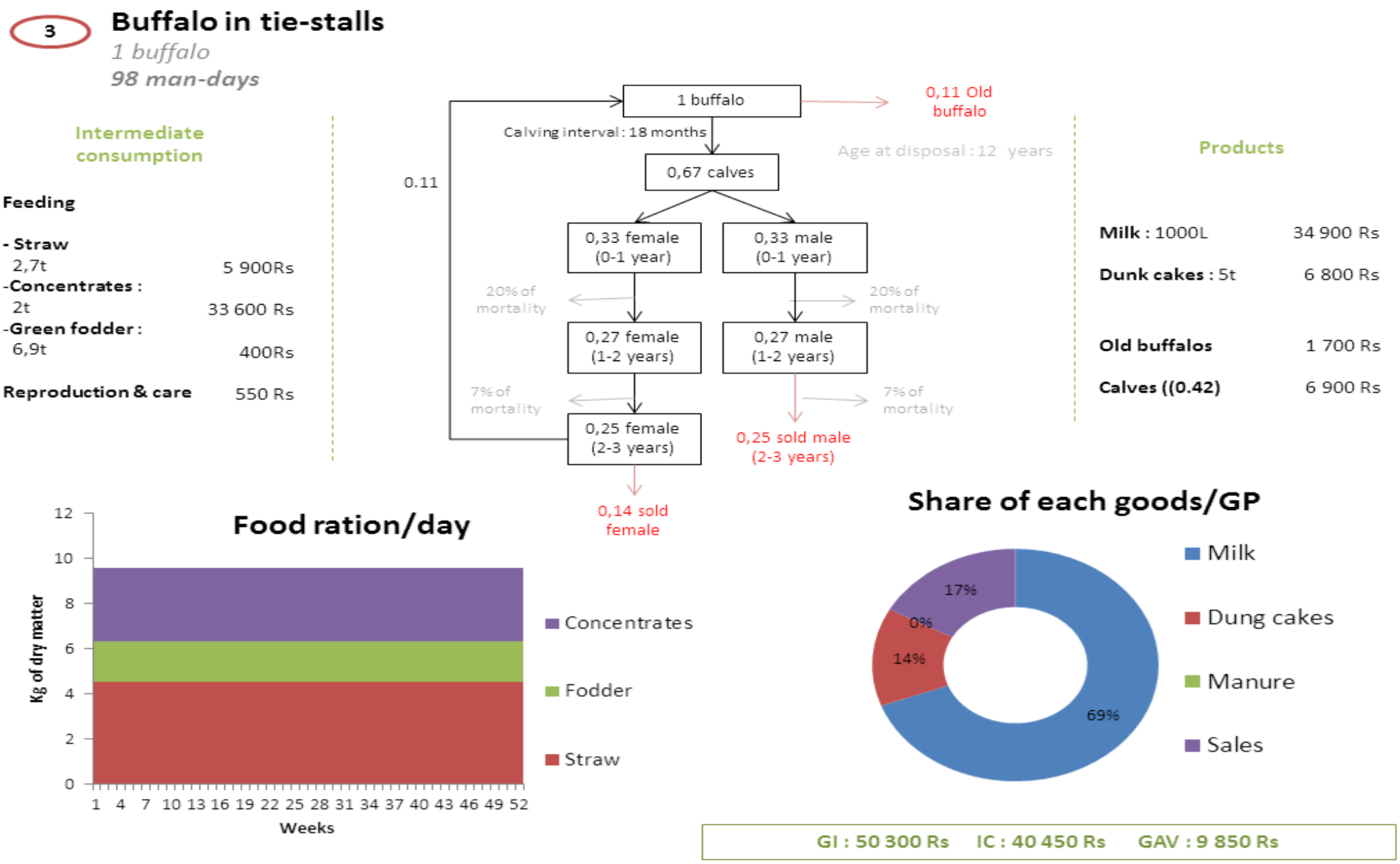


Figure 65: 2 cross-breed cows in tie-stalls

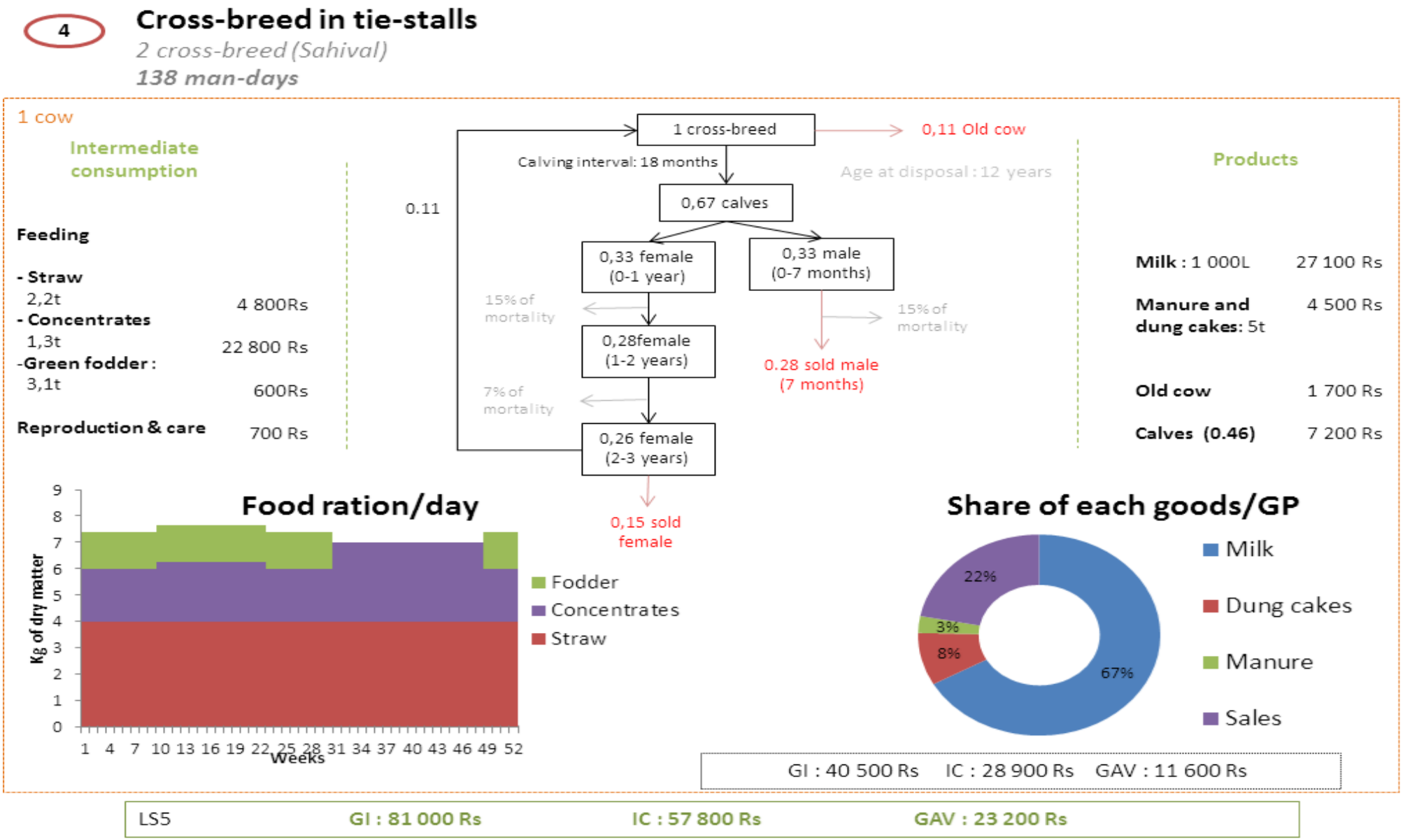


Figure 66: 4 cross-breed cows in middle dairy farm

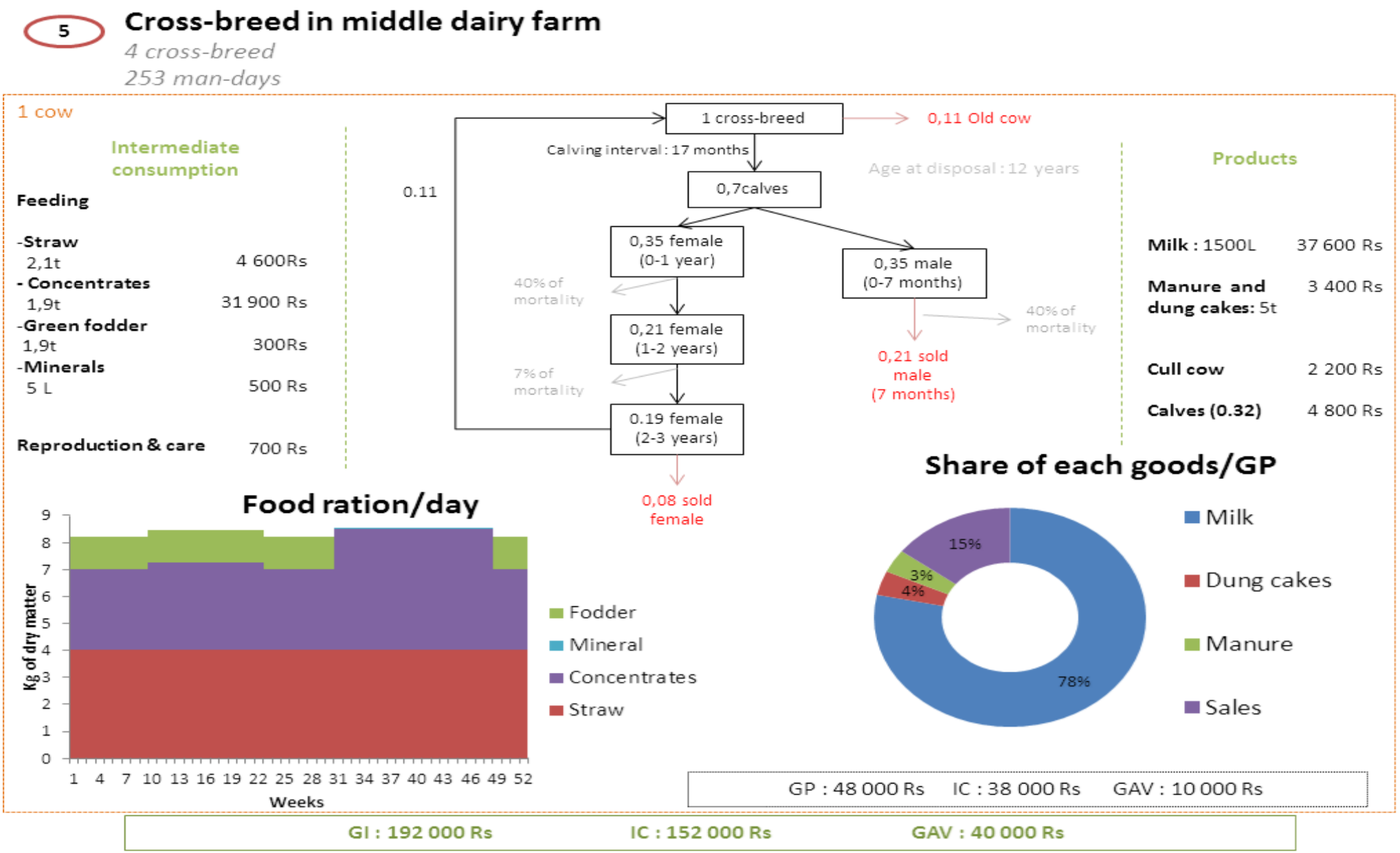


Figure 67: 7 cross-breed cows in big dairy farm

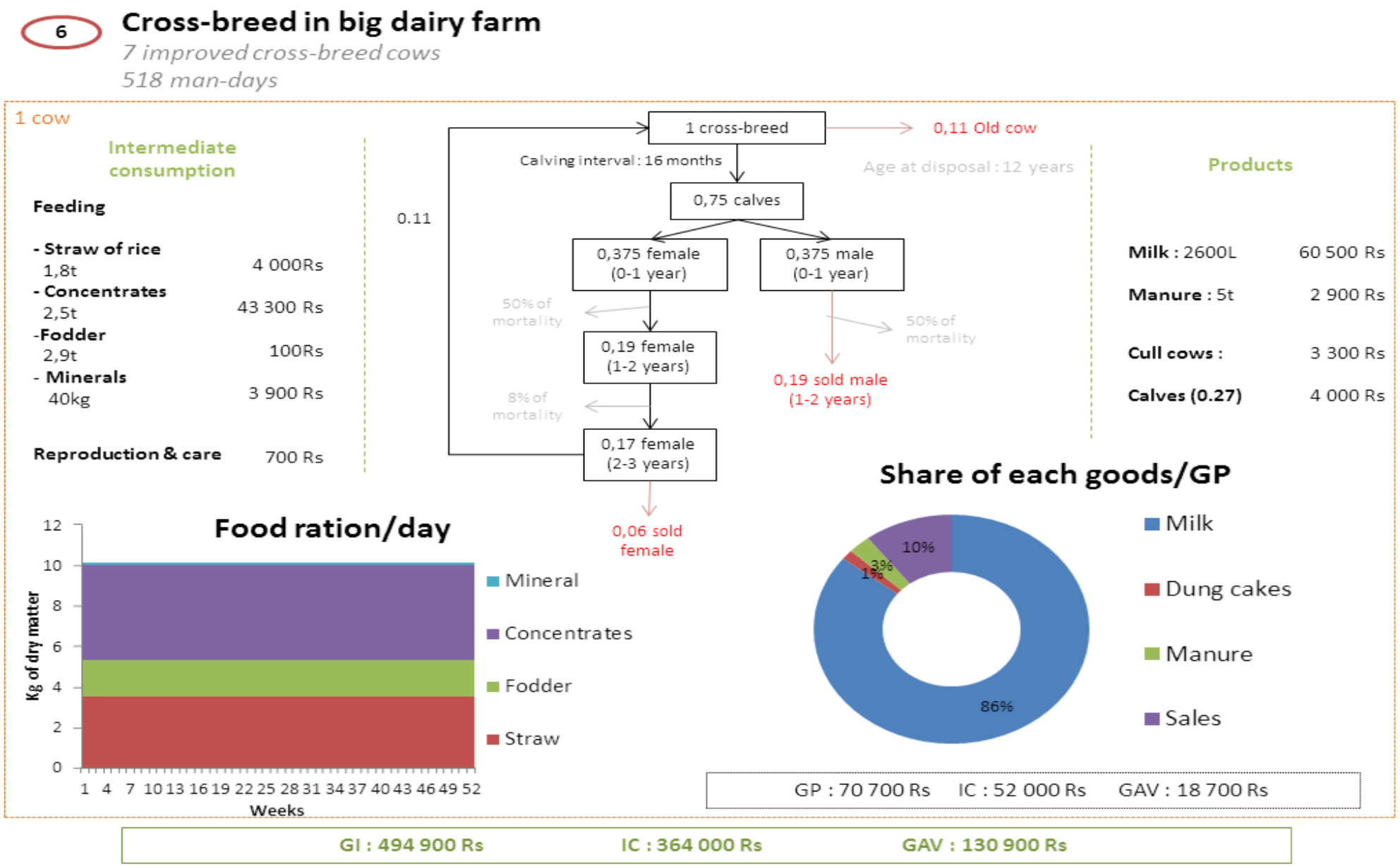


Figure 68: 3 goats

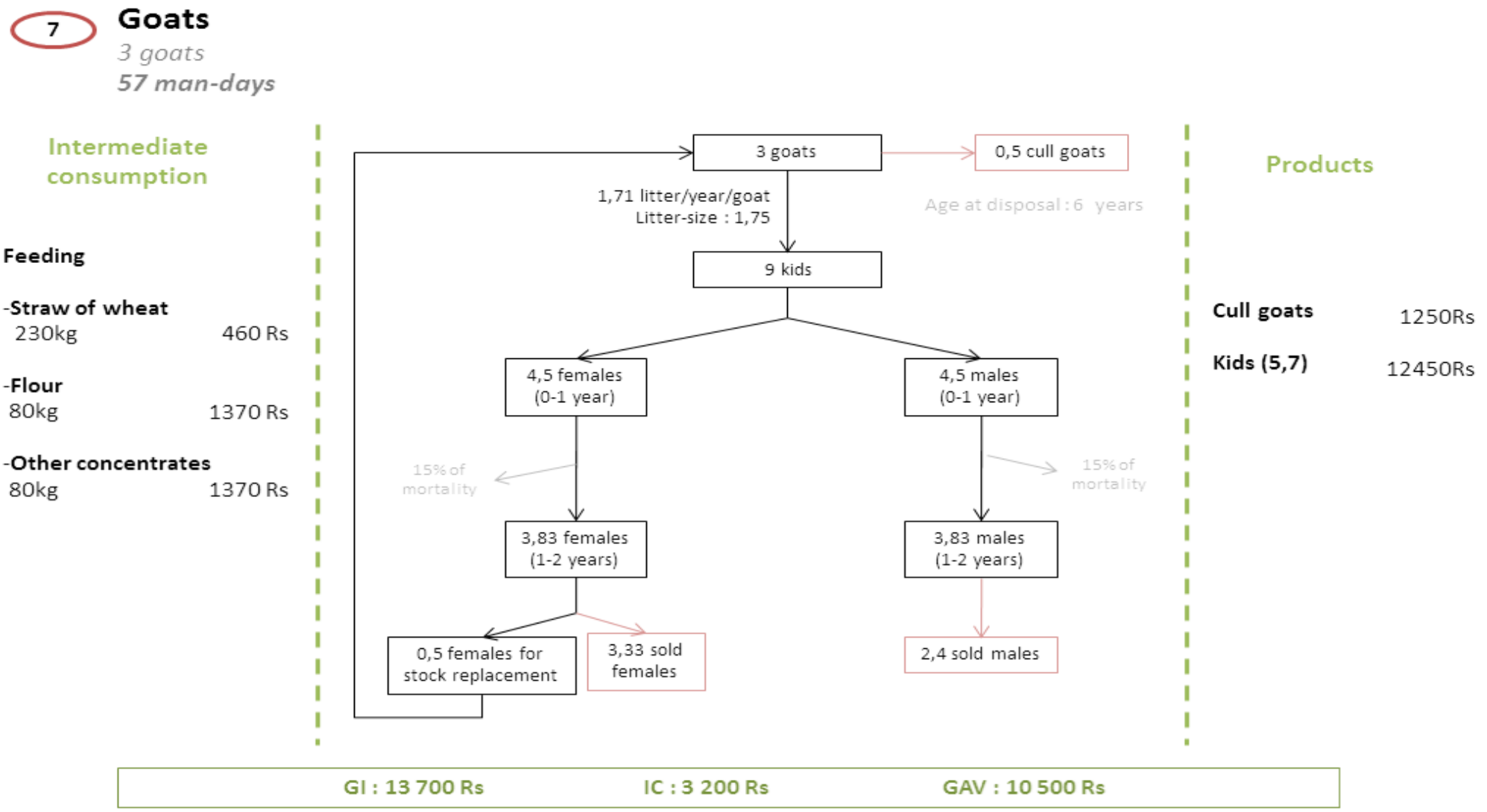


Figure 69: 2 hens

8

Chicken

2 hens

8 man-days

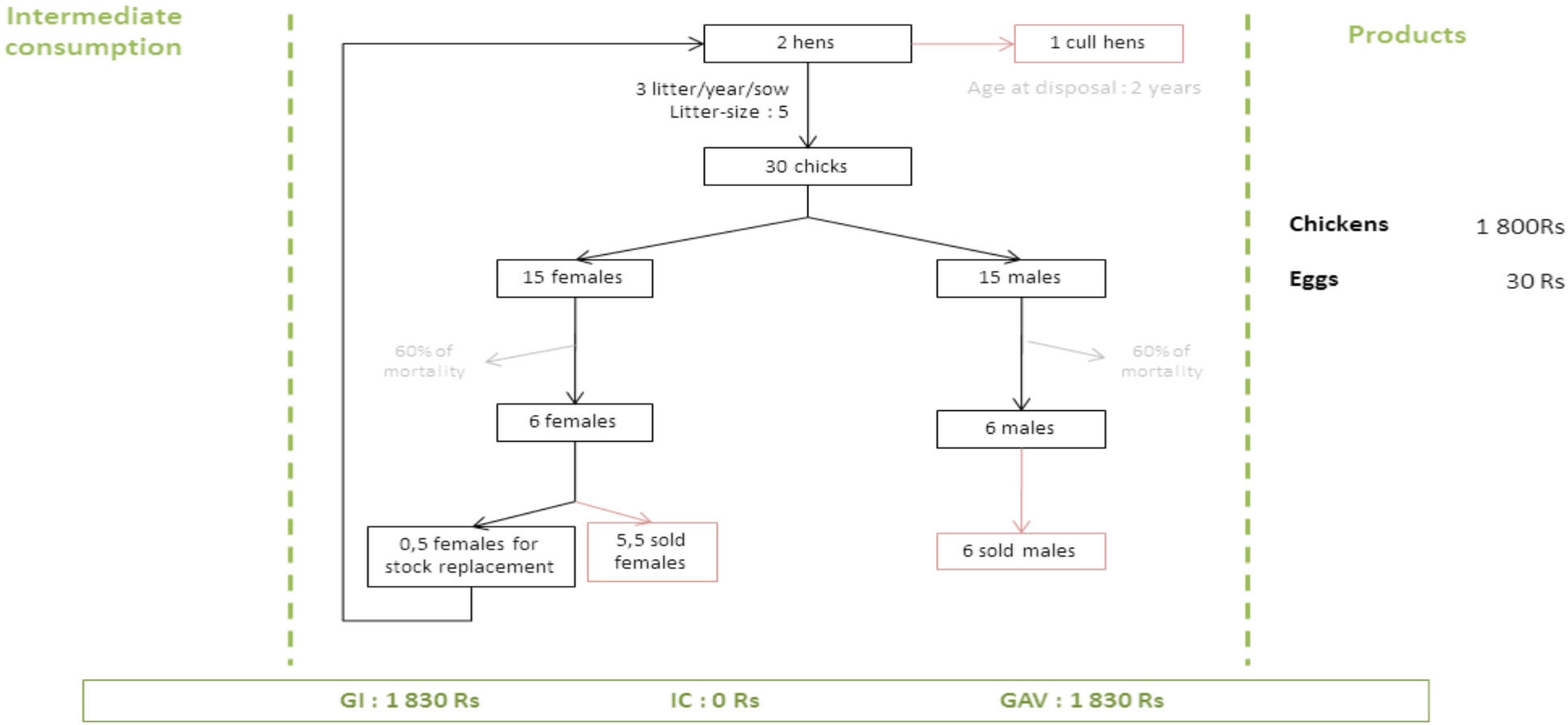


Figure 70: sheep herd

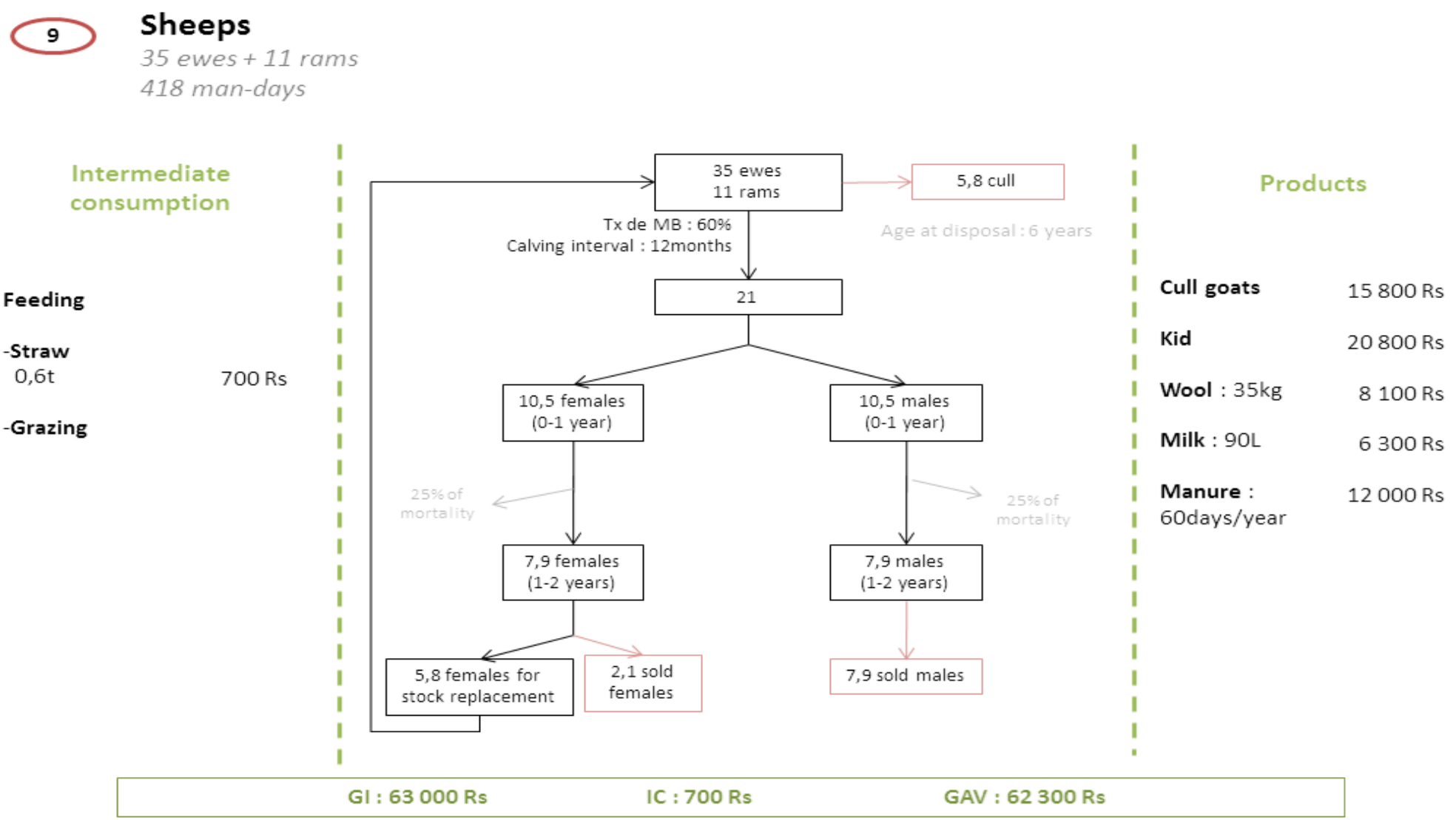
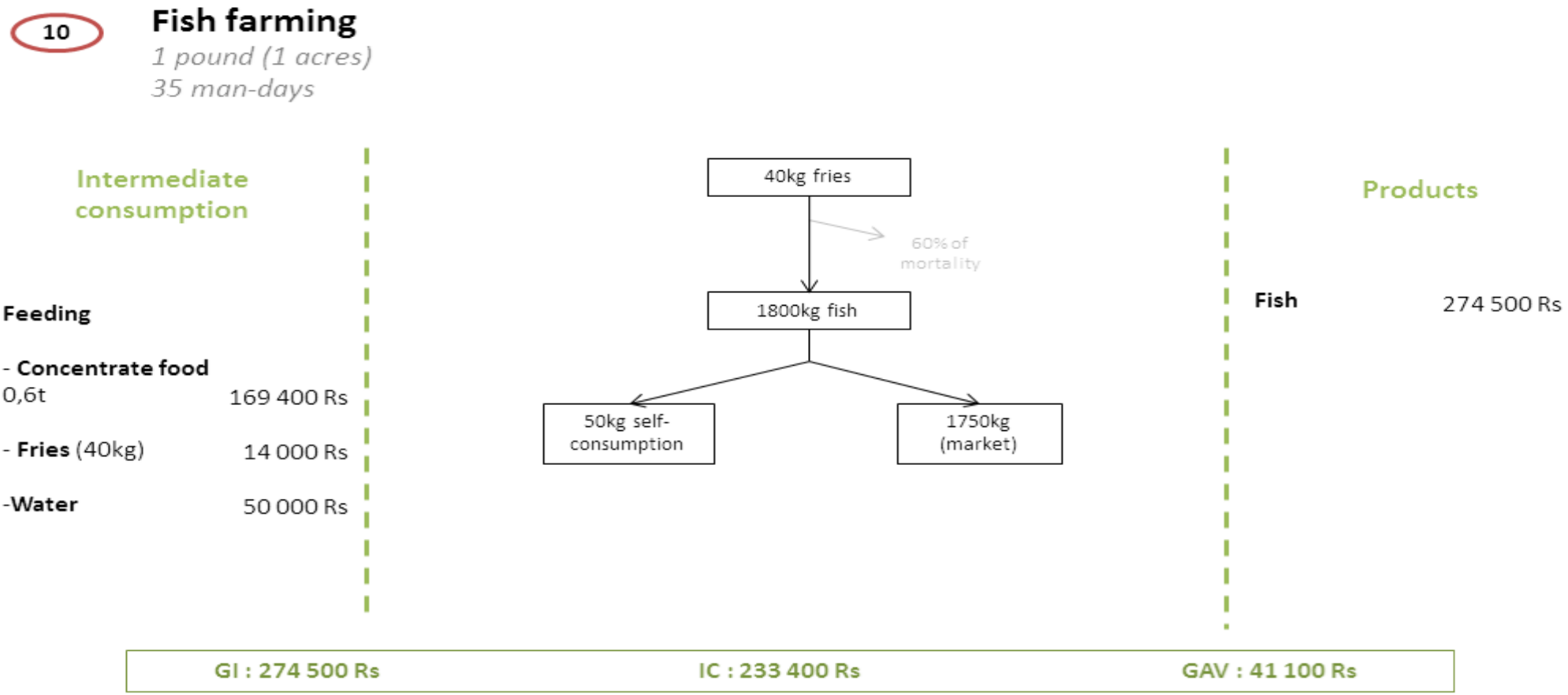


Figure 71: fish farming



Appendix E: survival threshold

Alimentary needs				
Type of food	Quantity	Frequence	Price (Rs/kg)	Total
Rice (breakfast, lunch)	1	day	27	9855
Wheat (roti, buiscut)	0.7	day	22	5621
Oil (mustard, rapeseed)	1	month	100	1200
Potatoes	1.2	day	9	3942
Onion	2	month	24	576
Pulses	2	month	60	1440
Winter Vegetables	4	week	10	693
Summer Vegetables	4	week	10	693
Mousson Vegetables	4	week	10	693
Fruits	10	year	30	300
Spices	0.75	month	40	360
Salt	0.75	month	30	270
Sugar	1	month	60	720
Milk	0.5	day	35	6387.5
Hygiene needs				
Type	Quantity	Frequence	Price (Rs/uni	Total
Soap	1	month	10	120
Toothpaste	3	year	100	300
Touthbrush	10	year	10	100
Shampoo	5	month	1.5	90
Shave	2	month	2	48
Hair cut	10	year	15	150
Detergent	1	year	300	300
Clothes				
Type	Quantity	Frequence	Price (Rs/uni	Total
Men T-shirt	3	year	50	150
Chemise	4	year	150	600
Children T-shirt	3	year	75	225
Children pant	2	year	150	300
Man pant	1	year	200	200
Underwear	5	year	50	250
Saree	1	year	300	300
Jacket	2	year	400	800
House clothe (man)	1	year	150	150
Shoes	5	year	200	1000
Others				
Type	Quantity	Frequence	Price (Rs/uni	Total
Electricity		month	200	2400
Ligth (ampoule)	2	year	15	30
Oil light	1	year	300	300
school material	2	year	400	800
cook material	1	year	400	400
Health				
Type	Quantity	Frequence	Price (Rs/uni	Total
Medecines	4	year	200	800
Doctor consultation	2	year	100	200
TOTAL				**42764.5**

Survival threshold with BPL cards

Alimentary needs				
Type of food	Quantity	Frequence	Price (Rs/kg)	BPL Total
Rice (breakfast, lunch)	1	day	3	5535
Wheat (roti, buiscut)	0.7	day	2	3221
Oil (mustard, rapeseed)	1	month	100	1200
Potatoes	1.2	day	9	3942
Onion	2	month	24	576
Pulses	2	month	60	1440
Winter Vegetables	4	week	10	693
Summer Vegetables	4	week	10	693
Mousson Vegetables	4	week	10	693
Fruits	10	year	30	300
Spices	0.75	month	40	360
Salt	0.75	month	30	270
Sugar	1	month	60	720
Milk	0.5	day	35	6387.5
Hygiene needs				
Type	Quantity	Frequence	Price (Rs/uni	Total
Soap	1	month	10	120
Toothpaste	3	year	100	300
Touthbrush	10	year	10	100
Shampoo	5	month	1.5	90
Shave	2	month	2	48
Hair cut	10	year	15	150
Detergent	1	year	300	300
Clothes				
Type	Quantity	Frequence	Price (Rs/uni	Total
Men T-shirt	3	year	50	150
Chemise	4	year	150	600
Children T-shirt	3	year	75	225
Children pant	2	year	150	300
Man pant	1	year	200	200
Underwear	5	year	50	250
Saree	1	year	300	300
Jacket	2	year	400	800
House clothe (man)	1	year	150	150
Shoes	5	year	200	1000
Others				
Type	Quantity	Frequence	Price (Rs/uni	Total
Electricity		month	200	2400
Ligth (ampoule)	2	year	15	30
Oil light	1	year	20	20
school material	2	year	400	800
cook material	1	year	400	400
Health				
Type	Quantity	Frequence	Price (Rs/uni	Total
Medecines	4	year	200	800
Doctor consultation	2	year	100	200
TOTAL				**35764.5**

Abstract

The present report is an agrarian diagnosis achieve in the south of Patna. It allows explaining farm diversities, through the understanding of landscape and the history of the study area.

The Green and the White Revolution have changed the agriculture in Bihar. Nevertheless, they are not the only explanation of farm diversities. Landscape and social organisation have their share of responsibility. For example, access to water is different through the block and in a village. It depends on the groundwater level and the wealth of the farmers. This access to water influences growing of cropping systems. Indeed some crops, such as paddy, wheat and vegetable, need lots of water.

Vegetables are one way to intensify the production and increase the growth product. Another way could be the dairy sector which has been developed by Sudha cooperative since 2003. This dairy cooperative has created new markets and new perspectives. However, these opportunities appear unreachable for the poorest people. Lack of financials means, lack of access to water and access to land are the main reasons. Some ideas are studied in order to submit new dynamics and opportunities.

Key words: Bihar, Agrarian diagnosis, Green Revolution, White Revolution, Sudha cooperative, access to water.