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PREVENTING WATER POLLUTION BY DAIRY BY-PRODUCTS: RISK ASSESSMENT AND COMPARISON OF LEGISLATION IN BENIN AND SOUTH AFRICA

by

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Submitted in partial fulfilment of the requirements for the degree of
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DEDICATION

To the Almighty God

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DECLARATION

I, Leopoldine E.S Abul Goutondji, hereby declare that the work on which this thesis is based, is original and that neither the whole work nor part of it has been, is being, or shall be submitted for another degree at this or any other university, institution for tertiary education or professional examining body.

Signature: _______________

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SUMMARY

Title:

PREVENTING WATER POLLUTION BY DAIRY BY-PRODUCTS: RISK ASSESSMENT AND COMPARISON OF LEGISLATION IN BENIN AND SOUTH AFRICA

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Institution: University of Pretoria

Key words: Dairy farming systems in South Africa and Benin - Water pollution - HACCP- Risk assessment - Legislation and strategies.

Abstract

South Africa (SA) and Benin have in common a desire to produce milk and dairy products in line with international norms and guidelines while protecting the environment (DE, 2003, 2004, 2005; Fedics, 2006; Jordan & Kraamwinkel, 2007; MAEP/ DE/ PDE III, 2004 (a) and (b)).

The increase in dairy production observed in South Africa and in Benin, both developing countries and situated in sub-Saharan Africa, should take into account the potential hazards linked to water pollution (Steinfeld *et al.,* 2006; FAO, 2007(b) and (c)).

The aim of the study was to assess the risk of water pollution through developing dairy production in SA and Benin by comparing appropriate and relevant legislation. The method chosen for this comparison was the Hazard Analysis; Critical Control Point (HACCP) based approach with some principles of environmental risk assessment. This is the method used by Horchner *et al*., (2006) for identification of CCPs in feedlot cattle.

In commercial intensive farming systems represented by F1, F2, F3 in South Africa, and F7 in Benin, potential hazards emanate mostly from water use (housing, service, cleaning of parlours and barns). Although chemical hazards (detergents, disinfectants, stock remedies residues and nitrates), as well as biological hazards (microbiological and macro biological) might also be a serious threat for water quality, if control measures are not sufficient, the prerequisites for registered stock remedies in SA mitigate the risk of chemical hazards. In Benin, the F7 farming system is under the control of veterinarians, so this also mitigates chemical hazards through residues.

In traditional farming systems represented by F4 in South Africa, F5 and F6 in Benin, the most significant physical hazards emanate when cattle drink from natural sources and at a lower level from pasture. The same hazards are also observed in F3 farming system that is an informal commercial system. Biological hazards due to deficiencies in animal health care can also be significant. Chemical hazards are better controlled in South Africa (because of the prerequisites for registered stock remedies) than Benin, where there is a trade in “black market” stock remedies and antimicrobials, facilitated by transhumance.

In South Africa sufficient legislation exists for the majority of the CCPs recorded. However deficiencies in the implementation of this legislation have been noticed for the containment of dairy run-off on farms as well as the use of chemicals (CCP 11 and CCP12), which are both related to environmental care.

In Benin, dairy farming systems remain mainly traditional, except in F7; the existing legislation is not sufficient to cover the majority of CCPs recorded, as well as GAP, GDP and GMP which are just being introduced in dairy farming practice.

It was recommended that in South Africa, the implementation of the relevant legislation regarding environmental care at farm level needs to be improved and better implemented, in line with the international norms and standards because South Africa has a significant commercial dairy farming sector (Burger, 2005/2006; Glawzeski, 2005; Strydom *et al.,* 2001; Slabbert, 2007).

In Benin it is suggested that, although water pollution by dairy production is not a short-term risk, the legislation should be updated, completed and adapted to the current strategy of improving dairy production (GWP/WAWP, 2006; Onibon *et al*, 2006).

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CHAPTER 1

INTRODUCTION

1.1 Background and Motivation

1.1.1 Background.

The concept of food quality has been changing in the food industry. Over many years, activities related to the production and processing of food of animal origin, and specifically milk and dairy products, have been improved. Several systems such as *Good Health Practices (GHP)*, *Herd Management and Health (HM and HH)*, *Good Agricultural practices (GAP)*, *Good Manufacturing Practices (GMP)*, *Good Fabrication Practices (GFP)* and *Good Dairy Farming Practices (GDP),* have been implemented (Brand *et al*, 2001; Buss *et al.*, 2006; Guard and Brand, 1996; Schillhorn van Veen, 2005).

In the relevant guidelines, various aspects are being taken into account to raise nutrition and living standards through improved agricultural production and rural development. The dairy sector is included in this and thus covers not only milk production but also a broad variety of issues related to dairying which involve multidisciplinary, scientific and technical expertise (FAO / IDF, 2004).

Many strategies (regulatory or not) have been developed to control dairy production and processing. They are conducted separately or jointly and refer to the main following issues: dairy farming, emerging countries, technology, hygiene and safety, food standards, methods of analysis, nutrition and health, economics, environment, marketing and policies (Droppers, 2006; EEC, 1993; FAO / IDF, 2004; FAO & World Bank, 2006; FAO, 2002 (a, b, c); IDF, 2007)

These strategies were traditionally fragmented and based on inspection, control measures and corrective actions on the final product. However, since 1993 the Hazard Analysis and Critical Control Point (HACCP) system has been introduced into the food industry to control and mitigate the risks along the food chain (EEC, 1993).The Codex Alimentarius Commission (CAC, 1997) later proposed 12 steps in the HACCP plan (Luning *et al.*, 2002). Data obtained from routine surveillance for food associated diseases showed that diseases in humans due to *Campylobacter sp, Salmonella sp, Shigella sp, Yersinia* sp and *Listeria* sp decreased after 1996 due to the introduction of HACCP in the food industry in the USA (Pappaioanou, 2004).

HACCP is a system based on preventive analysis from "*farm to fork*" according to a logical sequence. This system has been developed to correct and reduce the weaknesses of the traditional control systems based on inspection of the final product (Bauman, 1992; Dornom, 2004; Horchner *et al.*, 2006; IAMFES, 1991; Lievaart *et al.,* 2005).

Norms and standards related to milk and dairy product are the foundation of regulatory measures, which are monitored mainly by the following international organizations, which frequently work together:

- WHO (World Health Organization),
- FAO (Food and Agriculture Organization),
- OIE (Office International des Epizooties/ World Animal Health Organization),
- WTO (World trade Organization,
- IDF (International Dairy Federation)

Water, together with soil and air, are the most important environmental resources in danger. Added to the improvement of food quality and the reduction of food insecurity, an important goal of the above organizations is the reduction of water pollution and waste. This includes related diseases, the conservation and sustainable use of natural resources and the optimization of the health benefits of sustainable water resources and waste management (Braden & Lovejoy, 1990; Delgado *et al.*, 1999; FAO, 2002 (a), 2003; FAO & World Bank, 2006; Mwangi & Omore, 2005; Steinfeld *et al*., 2006; Upton & Otte, 2004; WHO 2000(a),).

Since the last century, water resources are becoming scarcer although they are unequally shared. The sources of non-saline water have been evaluated at 2, 5 % of the total water on earth and only 3% of this is available. Among the reasons for the scarcity of water are pollution, drought and soil erosion, which causes rapid run-off into the ocean (Steinfeld *et al.*, 2006).

Of specific interest to the veterinary profession, is the role livestock plays in water pollution as well as the effects that water pollution has on livestock health and the safety of livestock products (Brand *et al*., 2001; Casey *et al*., 1998, Casey & Meyer, 2001; FAO/WHO, 2002; FAO & World Bank, 2006; Steinfeld *et al.*, 2006). This is critically important in dairy production and processing (Abdussalam *et al.*, 1962). A great deal of water is utilized in the whole food chain, from drinking water for animals to washing of facilities, as well as effluents, which include manure and slaughterhouse wastes. Even milk itself can be a source of water pollution if discarded. Production of value-added dairy products (such as yoghurt, butter, whey and cheese) adds to this pollution risk. The veterinarian consequently has an obligation, not only to the animal production industry, but also to understanding the impact of this industry on the environment (Brand *et al*., 1996).

The *Guide to Good Dairy Farming Practice* developed and published by the FAO/IDF in 2004, mentions that milk production should be managed in balance with the local environment surrounding the farm (FAO / IDF, 2004).

Two main points mentioned by Schmidt & Van Vleck (1988), are that all dairy farms should:

- have an appropriate waste management system (including storage of wastes and disposal of manure).
- ensure that dairy farming practices do not have an adverse effect on the local environment.

The second of these includes control of run-off, limited and careful use of pesticides and stock remedies and ensuring that the operation gives an overall appearance of good hygiene (Abdussalam *et al.*, 1962).

International, national and local regulations which play a primary role in the protection of water resources and the environment cannot be implemented without considering a (HACCP) investigation of the animal production systems that impact on water quality (Bauman, 1992; Kirby *et al.,* 2003; Kofer *et al.,* 2004; Libby & Bogges, 1990; Lievaart *et al.,* 2005; Owen *et al.,* 2004; Segerson, 1990).

The different points developed above concern both SA and Benin. Even if the situations in the two countries differ; they have in common a desire to produce milk and dairy products in line with international norms and guidelines, while protecting the environment. If water becomes too polluted, dairy farming is not practical, as potable water is required throughout the process (Borland, 2004; Braden & Lovejoy, 1990; Brand *et al*., 1996, 2001).

This study will use a literature review and HACCP-based approach, together with observation of the farming systems involved in milk production and processes in both countries. Dairy farming systems will be described in both countries. Flow diagrams of the steps in the specific dairy farming system will be drawn and they will be used to identify and characterize the existing and potential hazards in each of the different dairy farming systems in both countries, especially with regard to water pollution. Once these hazards have been characterized, critical control points will be identified. From there, the legislation will be studied to see if sufficient control measures and regulations to mitigate the identified risks are included in existing laws. The level of implementation of the existing regulations in both countries will be discussed.

International standards and norms, such as those listed by the Word Health Organization (WHO) and the Food and Agricultural Organization (FAO) of the United Nations, will be used as a benchmark. Suggestions will be made on how legislation could or should be changed so that the risk of water pollution is reduced. This will be done according to the specific strategy and regulatory situation in both countries.

1.1.2 Motivation

The subjects mentioned in the title suggest two approaches to food quality for the improvement of dairy production: hygiene and safety of milk on one hand protecting of water resources on the other.

In 1992, the EEC (European Economic Communities) issued the Directive 92/46 establishing the hygienic requirements for the production and marketing of raw milk, liquid milk for consumption and milk for the preparation of dairy products. According to these, cow's milk produced for consumption must comply with specific chemical and physiochemical parameters. The EU then produced provisions concerning milk production, milk collection and milk processing (EEC, 1993).

Up until ten years ago, milk quality control addressed mainly chemical composition; however, due to the increase in international milk trade, hygienic control has been included. The IDF publishes international norms and these are in line with the requirements of Codex Alimentarius (Codex) for milk and milk products. These apply internationally to commercial producers and processors (CAC, 2007 (a) and (b); IDF, 2007). Guidelines on analytic procedures required at in collection centres for small-scale dairy farming enterprises can be found in the publication "*FAO, Small-Scale Dairy Farming Manual*" (FAO, 1993, 2007 (a) and (b)).

Progressively, in the last decade, more and more emphasis world-wide has been put on food borne diseases. WHO and FAO are committed in the monitoring of these diseases, and the reduction of their effects on animal and human health (FAO/WHO, 2006 (b)). OIE is also involved in the minimization of the risk of zoonoses such as Brucellosis and Tuberculosis. Emerging harmful micro organisms, persistence of veterinary drugs and detergents in milk and the presence of Aflatoxin M1 (as a consequence of the growth of fungi in animal feed), are considered to be linked partly to environmental issues (FAO, 2003; FAO/WHO, 2002; Giangiacomo, 2000; OIE, 2007 (b); WHO, 2007).

Over the last decade, environmental characteristics and standards for the milk producers have also been introduced as criteria for food quality improvement (FAO/IDF, 2004). However, data and information associated with environmental risks related to production, of dairy products are not well known (Steinfeld *et al*., 2006*)*. The effects of activities on water resources are also not well established, although water quality is of prime importance in the production of good quality raw milk. Quality assurance has also evolved and the different strategies implemented are included in the traditional fields of interest of the veterinarian (Emond, 2006; FAO / IDF; 2004; FAO/WHO, 2006 (a) & (b)).

In SA as well as in Benin, food quality assurance is now more focused on the needs of the consumer (Van de Venter, 2006). Consideration of such issues as environment, ecosystem's health and animal well-being have also become part of the criteria of quality measured by risk assessments (FAO, 2003; ICRI-FAO, 2004; ISO, 2005).

Animal health control, animal food sanitation and quality control, and public health related to animal disease control, have traditionally formed part of the role of the veterinarian, who was considered as the principal actor in the control chain. Veterinary Science has always included human health within the field of Veterinary Public Health (VPH). Quality assurance of food of animal origin is part of this (Akakpo *et al*., 2006; Pappaioanou, 2004; Schwabe, 1984; Smulders & John, 2004; Sidibe, 2003).

The achievement of sustainable livestock production and food safety is now based on the concept of an integrated food chain quality and safety control program. This integration is characterized by the creation of a platform for multidisciplinary formal and informal exchanges of views between the role-players and stakeholders. The farmer is the first link in this network and the key quality controller on the farm. In this regard, the veterinarian is the most significant role-player (Giangiacomo, 2000; Mathot, 2004; ONMVB, 2004).

Although veterinarians have always shown complete commitment to the struggle against new and emerging zoonosis, they should use their competence to enhance a livestock systems approach where multiple variables, not just the diseases, are evaluated (Collins, 2004; Noordhuizen, 2004). Smulders and John, (2004), explained this point of view in the article "*Changes in the veterinary management of dairy cattle: threats or opportunities".*

SA is situated in the southern part of Africa, in a sub-tropical and arid area and is surrounded on three sides by the Atlantic and Indian Oceans**.** The scarcity of water resources is mainly caused by drought and soil erosion. The presence of developed animal production systems for commercial purposes such as dairy farms should be taken into account as a potential risk for pollution of water and the environment. Classification and analysis of the impact and relevance to the pollution of water by the dairy industry is an issue that should be investigated (AQUASTAT, 2005; Burger, 2005 & 2006; FAOSTAT, 2005 (a), (b), (c) & (d); SA Online, 2006).

Benin is a Western African country, geographically limited in the north by the river Niger and in the South by the Atlantic Ocean. The country is situated in the sub-equatorial area and has a sub-humid climate with a well-drained hydrographic net; the scarcity of clean water resources is thus mainly due to water pollution (ABE-LABEE-DE, 2005; Abul Goutondji, 2004). Dairy production is closely related to the existence of safe water resources which are scarce in Benin, as in SA, but for different reasons (AQUASTAT Benin, 2005 (c) & (d)). As an emerging commercial producer with a large potential and actual local market for dairy products, the legislation is in its formative stage. At this stage it should be analyzed for deficiencies in risk mitigation and management, using the South African legislation (as an existing commercial producer); as well as the OIE Terrestrial Animal Code (OIE, 2007(a)), Codex Alimentarius (CAC, 2007(a)), the FAO Guidelines for Good Dairy Farming Practice (FAO / IDF, 2004) and international standards for water quality and environmental health, for comparison. A brief summary of the existing dairy systems in SA and Benin follows below.

SA has a dual economy with highly sophisticated intensive farming (dairy being a prime example) and extensive ranching or traditional livestock management on communal grazing. With more than 13,8 million of heads of cattle and 26 million goats, ownership ranges from one or two animals among subsistence farmers to over 10,000 in feedlots (FAOSTAT, 2005 (c) & (d); NDA, 2006). In SA, since the arrival of the Dutch in 1652, a number of European and British breeds of livestock have been introduced and crossed with indigenous breeds to form a nucleus of animals used in commercial systems. This, together with traditional cattle systems, the cultural value of cattle in Africa and the existing open spaces, explains the variety of dairy farming systems in SA, from the large commercial dairy farms to small-scale or household subsistence milk production. All farming systems are sedentary and there is no transhumance in SA (Maree & Casey, 1993; NDA, 2006[1]; SA Government, 2006).

Even if milk production represents only 0.5% of the world production, it represents 5% of the national GDP in SA (Gross value R 3862), 17% of the animal products and 7% of the total agricultural products.

[1] www.nda.agric.za/docs/Trends

Livestock is the fifth largest agricultural industry with a milk production of 2000 million litres, and a total consumption of 1950 million litres per year (ICAR[2], 2007).

In 2004, the total number of dairy cows in SA was 520 000.The average numbers of cows per herd was 115 heads and the average production per cow was 4744 kg per year. Commercial dairies usually comprise 200 to 1500 cows in milk (FAOSTAT, 2005(c)). A small - scale dairy farm was defined as one that produces up to 500 L of milk per day on average (Manzana, 2007). Dairy farming is sufficient to meet domestic needs except during periods of extreme drought (Country Studies US, 2006[3]; FAOSTAT, 2005 (c) & (d); IFCN[4], 2005).

Environmental aspects mainly involve droughts, water scarcity and soil erosion. There are two current water-related environmental issues in Southern Africa. Firstly, there is a lack of arterial rivers or lakes, which requires extensive water conservation and control measures; at the same time the increasing water usage by a burgeoning population threatens the water supply. Secondly, pollution of rivers from agricultural runoff and urban discharge are becoming a major threat to South African water resources (Country Studies US, 2006)[3].

SA has one of the lowest producer prices for milk in the world. However, although it has a strong commercial dairy farming sector, that has produced and exported dairy products for over a Century, it is actually barely self sufficient and is a net importer of milk and dairy products (IFCN[4], 2005). Since 1999, the production of commercial milk products is decreasing because the feed costs for intensive milk production as well as the inputs have dramatically increased (FAOSTAT, 2005 (c) & (d); NDA, 2003 & 2005).

Private companies controlled by the government, handle environmental impact assessments. Water pollution due to dairy production and processes is thus under the control of the government through its proposed National Water Strategy, the implementation of which is based on the Water Act 36 of 1998 (AQUASTAT, 2005 (a) & (b); S.A Government, 2007).

[2] http://www.icar.org/
[3] www.countrystudies.us/southafrica
[4] http:// www.ifcndairy.org

SA has been involved in the marketing of dairy products for a long time, so the HACCP concept and quality insurance have been legally implemented in several factories (Country Studies US[3] , 2006; NDA, 2006).

In Benin, there are pastoral, agro-pastoral and sedentary farming systems. Transhumance remains an integral part of cattle farming throughout the whole of West Africa. Although the management of the livestock system remains extensive and traditional, it has been influenced by changes over the last twenty years. Benin is densely populated, humid and with high ambient temperatures and rainfall. Under such conditions, improved milk production stands a good chance for success as feed for the cattle would be easily produced. The main risk of pollution would be linked to the manufacture of dairy products, either using local or imported milk, as highly intensive systems, as seen in Europe, would be impractical. After a pilot phase that began in 1990, some programs for the development of dairy production were initiated in 1994 (Ahomlanto & Lhoste*,* 2005; CIENI, 2004; FAO/TCP, 2005; MDR/DE/DRH/DIFOV-MEN/UNB/FSA/CIA-CSR, 1994; Partenariat-GRET, 2003).

Benin has a livestock count of 1 689 000 head of cattle and 1 995 884 head of small ruminants (DE, 2003; FAOSTAT, 2005 (a) & (b)), mainly spread in the northern - Borgou, Alibori, Atacora, Donga - and the central areas - Zou, Collines - of the country.

The local cattle breed *Borgou,* can produce 2.5 L of milk per day, while feeding a calf, in the traditional system and 4 L/day, also while feeding a calf, under the improved system of livestock management, mainly due to better nutrition and health. The milking period is 8 months (Rakotoarijaona, 2005).

Only 45% of the cattle are females of reproductive age and the fecundity rate is estimated at 60%. Animal health is well maintained due to regular vaccination by the veterinary services. The farmers are aware of the necessity for a regular health care program for their animals. The total milk production in 2003 was evaluated at 126 824 tons representing a milk consumption of 15 L/person/year (Partenariat/FSA-GRET, 2003).

Compared to regional and international production, milk production in Benin is low. The deficit of this production represents one third of the consumption (Rakotoarijaona, 2005). Importations of dairy products have been rising to reach the demand in dairy products.

The current levels of demand for milk and milk products are high compared to what is available and milk production should thus be developed (Von Massow, 1989). The high population growth rate (3 - 4%) and the high price of imported dairy products are a justification for the development of dairy production in Benin, because milk and the traditional cheese called *Wagashi*, play a major socio-economic role. Fresh and sour milk and *Wagashi* cheese are the main source of proteins for the pastoral and agro- pastoral people during almost eight months of the year (April to December). Then the cows are dried off and the people rely on *Wagashi* cheese during the next four months. Although both sedentary farmers and pastoralists occasionally slaughter chickens, guinea fowl, sheep and goats, this is not a main source of protein. Calves are reared on the cows, as is traditional in SA as well (Manzana, 2007). Bull calves that are not used for breeding are kept up until about 2-3 year of age and then sold. Only old female and male cattle are slaughtered for meat (Kees, 1996; Rakotoarijaona, 2005).

Dairy production is currently one of the priorities for development of livestock in Benin (MAEP/DE/PDE III, 2005; FAOSTAT, 2005 (a)) and various national programs have been implemented to promote a modern system of milk production. Three of the four national state farms of Benin are concerned with the genetic improvement of breeds: selection of pure breeds, crossing and distribution of improved animals in rural areas are the main components of the PDE III (*Projet de Developpement de l'Elevage Phase III)* Program, which started in 2002 (MAEP/DE/PDE III, 2004 (a) & (b)).

The milk chain is not yet as well implemented in Benin, as it is in the neighbouring countries of Burkina Faso, Niger and Mali, although, as explained above, there have been concerted government efforts, oriented towards development of milk production over the last ten years (ECOWAS, 2006; Houndonougbo, 2002; Partenariat-GRET, 2003; UEMOA, 2006). Dairy industries manufacturing yoghurt are located in Cotonou, the main city of Benin (CIENI, 2004; FAOSTAT, 2005(a) and (b)). They have been observed to be small in size and use imported powdered milk.

Since 1997, when the first draft of the Environmental Action Plan and the Environmental Policy were promulgated in Benin, environmental issues (specifically water pollution) have been managed by the Ministry of Environment, Habitat and Town Planning (MEHU), the Ministry of Home Affairs, the Ministry of Agriculture, Livestock and Fisheries as well as the Ministry of Public Health and the Ministry in charge of Energy and Hydraulics. Impact assessments are implemented by the "*Agence Béninoise pour l'Environnement*" (ABE/MEHU[5], 2003) and various role-players interact in environmental cells.

[5] Website http://www.mehubeninnet

Implementation of waste - water management is recent and veterinarians are not yet systematically involved in the monitoring of this management. After the change of government in 2006, some of these institutions have been renamed[6] .

HACCP is implemented and controlled by the CEBENOR/MCIPME (*Centre Beninois des Normes*) which is administrated by the Ministry of Trade, Industries and Less Developed Business. However milk and dairy products are not yet included in the implementation of HACCP (Personal observation, 2006).

In short, many strategies for dairy development in tropical and sub tropical areas (where both SA and Benin are situated), have been recorded (FAO, 2002 (b); ICRI-FAO, 2004; MAEP, 2004; Matthewman & Chabeuf, 1993). Like Slabbert, (2007), whatever the strategy or the regulation, many authors agreed that "*raw quality milk is the first step in the quality chain and therefore a good raw milk quality control system is of utmost importance in milk production and milk processing*" (Slabbert, 2007).

However, the implementation of specific aspects of strategies related to water pollution by dairy production and processes appears to be deficient and confusing.

This study has been initiated to investigate linkages, strengths and weaknesses of the legislation and policies governing water quality and pollution of water resources by the dairy industry. Even if neither of the two countries is in a critical situation due to the adverse environmental effects of dairy-by products, this research could allow a prospective view on the problem and highlight possibilities for improvement (Collins, 2004; FAO, 2002 (c) ; FAO/IDF, 2004). Proposals for good risk mitigation and management will be reviewed (FAO, 2002 (a); Faye & Loiseau, 2002; Horchner *et al*., 2006; Kirby *et al.*, 2003; Radostis, 2001; Robinson, 2002).

The envisaged benefits of this study include:

- a proposal for a model of risk analysis of the potential hazards in each specific type of dairy farm activities, for water resources in both countries, will be developed. The model will be designed according to the HACCP logical sequence. Flow diagrams and decision trees will be built and used for further risk analysis;

[6] www.gouv.bj/presse/jo/index.php, 2007

- the level of risk mitigation by the respective current legislation in both countries will be estimated: critical control points in line with the activities and the regulation will be determined;
- as SA is committed to international dairy trade, clarification of legislation pertaining specifically to dairy production and processing could result in an enhancement of quality control of dairy production and processes in line with current international norms and standards;
- Benin could use the South African experience relating to water conservation issues to review domestic regulations.

1.2. Research problems

According to a scenario put forward by the FAO in 2005, global world milk production is likely to increase, to meet increased demand and the developing countries would mainly be the leaders in future increases (FAO/CAF, 2005). This is relevant because SA is among the major producing countries in Africa and since the last decade, many efforts have been made in Benin, to increase milk production as the demand is increasing.

The development of livestock systems oriented to dairy production should be considered as a potential risk for the quality of surface and groundwater resources. In fact, these risks will increase as interest in production of milk and dairy products grows to meet demand (Casey & Meyer, 1998 & 2001; Collins, 2004; Countries Studies US, 2006; Delgado *et al.,* 1999; FAO, 2002 (b)*;* Meyer *et al.,* 1997; Zwart & de Jong, 1996).

A dairy farm produces a variety of wastes products, from urine and faeces, which are more or less diluted with rain water to become dirty water (mixtures of water, discarded milk, detergent and disinfectant in some cases). The problems caused to the environment by manure and other by-products in the milk producing chain are various and water pollution is a serious problem if and when it happens. Thus an effort should be made to avoid such problems (FAO, 2002 (b); Poupoulis, 2004; Steinfeld *et al.,* 2006).

In SA legislation related to dairy production and water pollution is well documented but the implementation of water pollution control in dairy farms is not well investigated (Steinfeld *et al.*, 2006; Strydom *et al.,* 2001). In Benin, however, legislation regarding dairy production and water pollution issues is extremely scarce (personal observation, 2006).

In Benin as well as in SA, veterinarians are not directly involved in the protection of water resources, although drinking - water quality is of serious importance to the main activities of animal systems (DE, 2003, 2004, 2005; Personal observation, 2006). In both countries several authors expressed the confusing situation in term of water pollution control as follows:

- Administrative fragmentation.
- Lack of holistic vision.
- Legal pluralism.
- Ineffectiveness of some law enforcement.
- Inadequate monitoring and inspection capacity. (Glazewski, 2005; Kidd, 1997; Onibon *et al.,* 2006):

One of the most powerful of the twenty-eight international environmental laws is about water and was enacted in 1970 by the Group Action Congress in USA during Earth Day. Since the adoption of the international "*Clean Water Act*" in 1970, most countries all over the world have tried to improve their regulations: SA and Benin are not an exception. However, the implementation in the target field (dairy production and processes) is not fine-tuned (Copeland, 2002).

In summary, SA and Benin face the same problem of scarcity of potable, drinking water even if the cause is different. It is necessary in both countries to protect water resources through the avoidance of additional problems. These problems can be summarized as follows: water pollution due to dairy production and the implementation of control measures for its prevention.

The above - stated problems induce some reflection from our side:

- We have to be able to describe and determine the situation of dairy production in Benin and in SA through a literature review, observation and in regard to the respective legislation.

- We also have to do a situational analysis of the extent and nature of potential risks of water pollution by dairy production activities.

- We also have to look at potential effects and risk mitigation linked to legislation in both countries.

- The final step at this stage concerns the management of the situation: how to use the logical sequence of the HACCP framework? The different steps of the HACCP framework could be adapted in accordance with the activities recorded in each type of farming system.

- Suggestions for risk mitigation should refer to the current strategies and policies in the countries, as well as the current and relevant international food safety and health issues, environmental and trade policies and legislation.

1.3 Hypothesis

That comparison of HACCP for all the production stages and specifically in dairy farming systems in Benin and SA, coupled with an examination of existing legislation in both countries, should allow for better risk mitigation in regard to water pollution, through suggested changes to legislation, particularly in Benin.

It would be possible, by examining dairy farming systems and water resources management (legislation) in Benin and SA, to identify risks of water pollution that are not managed by existing legislation and make a proposal for specific changes to reduce the risk.

1.4 Objectives

- The first objective is to investigate and document the dairy farming systems in SA and in Benin.
- The second objective is to identify and characterize the hazards to the water resources of both countries originating from dairy production.
- The third objective is to use HACCP methods to draw flow diagrams for the different farming systems for dairy production in SA and Benin.
- The fourth objective is to relate the hazards and critical control points (CCPs) identified in the production systems, to existing legislation, for the control of the dairy industry and water pollution in both countries. This step is actually the mitigation of potential hazards at CCPs.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Over many years, the environment has gradually become a focus of interest. Various concepts and words have progressively appeared in our everyday speech such as “ecology, ecosystem, biotope”, etc. Environmental issues, goals, objectives and trends have gradually evolved. Environmental issues have not always had the same importance in each country or area in the world. However the three main components of the environment (water, air and soil), are closely tied to animal and plant production, which are vital for food security and even survival (FAO, 2007 (b) & (c)).

For many decades, animal production systems have been improving globally (Radostis, 2001; Richards & Ku-Vera, 2007). Animal production management, animal health care, fabrication of animal products, monitoring and control systems for animal products, have evolved through various programs (CIRAD, 2007; Dornom, 2004; Hanak *et al*., 2000). Health Care (HC), Herd Health (HH), Production Management (PM), Quality Management Systems (QSM) and Heard Health Production Control Programs (HHPCP) are some of these programs. Their implementation differs in many aspects within developed countries on one side, or developing countries on the other side (Antle, 1999; ICRI-FAO, 2004; Kofer *et al.*, 2004; Zwart & de Jong, 1996). Some authors have focused on the economic impacts of technological changes in the agro-food production and processing sectors in sub-Saharan Africa, while others are interested in changes related to environmental issues, policies and strategies (Delgado *et al.*, 1999; Ghidini *et al.,* 2004; Emond, 2006; Steinfeld *et al.,* 2006*)*.

In regard to the issues of this study, the literature review contains ten main topics. These are:

- Livestock and dairy farming systems in SA and Benin.
- Dairy production in both countries.
- Laws and regulations in regard to milk and dairy products.
- Laws and regulations in regard to water pollution.
- HACCP in regard to milk and dairy products.
- The role of the veterinarian in regard to dairy farming and prevention of water pollution.

- International regulations, criteria, norms and standards.
- A review of risk assessment for water pollution.
- A review of risk mitigation and management for water pollution.
- An overview of policies, stakeholders and role players in dairy systems and water pollution.

2.2 Livestock and dairy farming systems in SA and in Benin

This section will describe the context of livestock and dairy farming in Africa and specifically in Sub-Saharan Africa where SA and Benin are situated.

2.2.1 The context of dairy production in Africa

Cattle milk production represents more than 91% of the world production of milk and is practiced everywhere in the world. It plays a major role as a source of proteins for human being and a socio-economic role in the communities involved with dairy production systems (Lambert, 1988; O' Connor, 1993; Ogodja, 1988).

In Africa, dairy production is mainly implemented traditionally, even if this is not well described in the literature. Local indigenous breeds are predominant and are used for many reasons: milk production, meat, manure, traction and savings. Fresh or sour milk is used mainly for the family; the rest may be sold. In the commercial sector, improved, exotic or crossbred cattle are used only for dairy production and marketing of heifers or bulls. The development of the commercial sector varies between the different countries of Africa (Duteurtre *et al.*, 2000 cited by Akuesson, 2001; FAO 1990, 1993; FAO & World Bank, 2006; Nyiransabimana, 2005).

Livestock products and particularly milk and dairy products are valued and marketed according to two networks: a traditional, informal network that is not well developed and formal officially recognized marketing channels, often linked to export markets. Africa is the lowest producer in the area of dairy products in the world; with 33.57 billions of tons in 2005, compared to a total of more than 650 billion tons for the rest of the world (FAO/CAF, 2005). Improvement of the dairy industry in Africa is mainly characterised by development of collecting networks, coupled with upgrading of the existing dairy breeds with imported bloodlines (FAO, 2002 (b); ICRI-FAO, 2004).

In general, dairy production is deficient in most of the countries of Sub-Saharan Africa and does not even meet local demand (IFCN, 2005). This commercial deficit has continuously increased since 1960 in sub-

Saharan Africa; the deficit was 39 million USD in 1963, 81 million USD in 1970 and 575 million USD in 1980. By that year, all the sub-Saharan countries were deficient in commercial dairy products. In 1984, this deficit was mainly ascribed to the increase in imports of dairy products: 41million USD in 1960, 104 million USD in 1970 and 705 million USD in 1980. In 2000 this deficit had been evaluated as 60% of the demand (Mbogoh, 1984). This was despite measures taken to improve production and processing of dairy products (Brumby & Gryseels, 1984).

The increase of imports was observed while the population and the demand for dairy products were increasing rapidly. The population annual growth rate was 2, 9% during the 70s, while dairy production growth was 1,9% and consumption increased to 2,1%. Global demand by sub-Saharan Africa for dairy products is increasing and different studies suggest that this trend will continue as local supply cannot meet the demand (IFCN, 2005). This has had a negative impact on the national agriculture-linked economics and sub-Saharan countries will continue to import milk powder, milk fat and whey, particularly for the urban areas, if the local production capacity does not increase (FAO & World Bank, 2006; Von Massow, 1989).

Since the 90s, the awareness of the above-mentioned situation progressively led sub-Saharan countries to review their agricultural policies and strategies for milk and dairy production.

Dairy production cannot be considered without clean water resources. The primary efforts made by the governments did not initially focus on water resources; however since the adoption of the Clean Water Act in 1970, African countries have become more committed to the protection of water resources. National strategies are progressively including water resources issues in agricultural planning. What also needs to be remembered is that intensive dairy production systems can also be responsible for pollution of water resources (AQUASTAT, 2005(b),(c) & (d); Brand *et al*., 2001; Casey & Meyer, 1998 & 2001; FAO & World Bank, 2006; HSUS, 2005; Michel & McCrindle, 2004(a); Steinfeld *et al.*, 2006).

Benin and SA are both in sub-Saharan Africa but their situation in regard to dairy farming systems and water resources presents many differences which will be described in more detail below.

2.2.2 Livestock and dairy farming systems in SA

2.2.2.1 Historical aspects

The historical aspects of SA's dairy sector can be divided into four periods and these are closely linked to the social, geo-climatic and political situation of SA (Byrnes, 1996; Steyn, 1999).

- Period 1: Until the seventieth century (1652), local breeds of livestock were traditionally reared by the Khoi people. These traditional systems were essentially extensive, nomadic and transhumant.

- Period 2: Since the arrival of the Dutch in 1652, a number of British and other European breeds of livestock (Friesian, Holstein, and Jersey) have been introduced and also crossed with the indigenous breeds.

- Period 3: Since 1980, SA has been part of regional and international organisations committed to livestock and animal health care.

- Period 4: From 1994 rapid changes have been observed throughout in the agricultural sector, and particularly in the dairy sector.

Droughts, soil erosion, and water scarcity have always formed been part of the environmental problems (AQUASTAT, 2005(a)). Water pollution has however only been taken seriously over the last two decades in SA. Prior to that, the main activities associated with water resources were oriented towards solving drought problems through irrigation and construction of dams. The promulgation of the Water Act in 1998, proved to be a turning point in the management of water resources in SA (AQUASTAT, 2005 (a); Country Studies US, 2006; SA Government, 2007).

Although SA exports dairy products, it does not always produce sufficient for the needs of the country and dairy products, particularly whey and milk powder, are also imported (NDA, 2003 & 2005).

2.2.2.2. Livestock and dairy farming systems in SA

- <u>Characteristics of livestock</u>

  The aspects of livestock issues in SA are related to the strategies of the agricultural sector:

Only 13,3% of the population of SA is concerned in agricultural activities and 13,5% of the surface area can be used for crop production; 1,3 million hectares (ha) are under irrigation. Agriculture represents 3,9% of the Gross Domestic Product (GDP) of SA and contributes about 7,5% to formal employment. Livestock is 46,2% of the agricultural GDP (FAOSTAT, 2005 (c); Gertenbach, 2007).

Farming systems in SA are limited by the water supply and range between highly sophisticated intensive farming (dairy being a prime example) and extensive ranching or traditional livestock management on communal grazing, depending mainly on the availability of rainfall and underground water (EIA 2003; NDA, 2003 & 2005). SA has a dual agricultural economy which is characterized by a well-developed commercial sector and a predominantly subsistence-orientated sector in the rural areas. Livestock is spread throughout the country, but the farming areas are mostly in the Northern Cape, the Eastern Cape, the Free State and the Mpumalanga Provinces, where the population is less urbanised. (FAOSTAT, 2005(c) & (d); SA Government, 2007).

- Dairy products

In SA, dairy products include fresh milk, sour milk, partly skimmed milk, skim milk, whey, whey butter, butter, butter oil or ghee, whey cream, cheeses, buttermilk, yoghurts, cream and ice creams. Most of these are manufactured by the commercial dairy industries, although there are a few small-scale producers of non-pasteurized milk and cheese, these have to meet very stringent controls on milk and cheese quality and food safety (NDA SA, 2003; FAOSTAT(c) & (d) 2005; SA Online, 2006).

- Livestock production systems

The country can be subdivided into several farming regions according to climate, natural vegetation, and types of soil. The main activities in farming practices related to dairy production are dairy farming and at a low level stock farming. Cattle-ranching is preferably practiced in the bushveld, and sheep-farming in the more arid regions. Numbers vary according to climatic conditions (FAO, 2007(a)). Livestock resources in SA are shown in Table 2.1.

Table 2.1: Cattle, sheep and goats in SA. Source: FAO, 2007(a)

Species	Year				Annual growth rate %	
	1980	1990	2000	2002	2001	2004
Cattle (1000's)	13,575	13,300	13,600	13,500	-0,2	0,2
Sheep and goats (1000's)	37,435	38,765	35,257	35,939	0,3	-0,9

The number of livestock according to province is shown below in Table 2.2.

Table 2.2: Estimated livestock numbers in SA (Source: SAMIC Newsletter No 32 of 16-09-2005).

Province	Cattle		Sheep		Goats	
	Aug-04	Aug-05	Aug-04	Aug-05	Aug-04	Aug-05
Western Cape	496	492	2798	2736	237	237
Northern Cape	468	476	6517	6395	590	560
Free State	2 253	2 281	5093	5160	223	221
Eastern Cape	3 042	3 072	7536	7629	2 489	2 487
KwaZulu Natal	2 749	2 813	782	775	908	922
Mpumalanga	1 347	1 359	1706	1724	102	98
Limpopo	1 138	1 192	223	212	1 052	1 049
Gauteng	273	278	95	92	42	45
North West	1 747	1 800	609	593	729	736
TOTAL	13 513	13 763	25 359			

It should be noted that these figures do not agree with the data on the FAO website, where the number of sheep and goats are estimated at approximately 35 million. The difference may be due to the inclusion of goats owned by communal farmers in the informal, as opposed to the commercial agriculture sector (McCrindle *et al.*, 2006).

Milk production in SA is represented in Table 2.3.

<u>Table 2.3:</u> Trends in annual production of milk in SA (1, 000 metric tons).
Source: (FAOSTAT, 2005 (c); MPO, 2007)

Milk Production	Year							
	1980	1990	2000	2002	2004	2005	2006	2007
FAO data	2,500	2,475	2,540	2,618	2,800	2,900	2,050	
MPO data					2,220	2,320	2,420	2, 370
Annual growth rate	-0.1%	0.3%	+1.9%		+1.9%	+3%		

The consumption of milk in SA is reflected in Table 2.4.

<u>Table 2.4:</u> Trends in annual consumption milk in SA.
Source: (FAOSTAT, 2005(c); (2) MPO, 2007

Product	Year							Annual growth rate (%)	
	1980	1990	2000	2002	2004	2006	2007	1980 - 1990	1990 - 2000
Milk, total (1000 metric tons)	1,518 (1)	1,366 (1)	1,801 (1)	1,793 (1)	2,210 (2)	2,340 (2)	2,480 (2)	-1,0	2.8

- Annual per capita consumption of milk was about 58 kg in 1980, and stabilized to 40 kg per capita per year between 1990 and 2002. In 2006 the total consumption per milk was 2 088 000 litres.

Dairy production in SA is characterized by a stable economy and excellent infrastructure. Although livestock health is well controlled by an extensive network of state veterinary services, dairy cattle face the threat of major transboundary diseases. There is a permanent risk of Foot and Mouth disease, which is endemic in wildlife in the Kruger National Park. Across the borders of SA, Contagious Bovine Pleuropneumonia and Rift Valley Fever are diseases' risks that must be considered when importing animals or animal products. Inside the country, Brucellosis and Tuberculosis exist in the local cattle population and the prevalence of mastitis is significant in commercial dairy herds (Coetzer & Tustin, 2005; McCrindle *et al.*, 2006).

- Economic aspects of livestock

The National GDP growth is 4,5% and the agricultural sector represents 3,4% of the Gross Domestic Product (GDP). The agro-industrial sector is estimated to represent 15% of GDP and the livestock industry is currently the largest national agricultural sub-sector. The local demand for products, which generally outstrips production, creates a dependence on imports, even though there are untapped production reserves in the communal farming sector.

Table 2.5: Trade in agricultural and livestock products in SA.
Source (FAOSTAT, 2005 (c))

Product	Exports				Imports			
	1980	1990	2000	2002	1980	1990	2000	2002
% agricultural	8,7	7.0	6.1	6.83.3	3.3	4.7	4.5	4.7
% livestock	1.0	0.6	0.4	0.6	0.6	0.8	0.7	0.5

The producer prices of animal products were 17,4% higher in 2002/03 than in 2001/02. The price of pastoral products increased by 25%, and that of dairy, by 11, 3% (NDA, 2003 & 2005; SA Government, 2007). Trade in agricultural and livestock products is shown above in Table 2.5.

- Nutrition

In SA, mixed alimentation of livestock is frequent. Big and small ruminants are generally fed on artificial pastures and roughage and/or silage is added to the feed. Animals are supplemented with minerals, vitamins and salt according to the objective of the livestock system. Natural pastures are frequently used for small-scale breeding herds (FAOSTAT, 2005 (c) & (d); Maree & Casey, 1993).

2.2.3 Livestock and dairy farming systems in Benin

2.2.3.1 Historical aspects

Benin is a Western African country where agricultural activities have been mainly extensive and traditional. Almost 70% of the population are involved in agricultural activities. Fisheries are found along the coastal areas, lakes and rivers. Some seafood factories exist in Cotonou, the largest city (FAOSTAT, 2005(a) & (b)).

The population of Benin was 3.3 m in 1979, to 4.9m in 1992 and 6.8m in 2002. Population growth-rate increased from 2,84% between 1979 and 1992 to 3,25% between 1992 to 2002. In twenty years, the population of Benin has doubled. In 2025 the Benin population is expected to have increased to 12 794 155 (INSAE, 2004, 2005).

The economic growth rate increased 4,3% between 1992 and 1995. By 2002, it was 5,6% mainly due to crop production. Cotton is the main export product in Benin and represents 90% of the export value. However, during the last five years the commercial balance was deficient, so efforts have been made to develop other agricultural sub-sectors such as dairy production (MAEP, 2004; MAEP/DE/PDE III, 2004 (a) & (b), 2005).

Until the last decade, livestock activities were located mainly in the northern and central parts of the country and practiced by the *Fulani* population. They chiefly comprised of large ruminants (almost 2/3 of the total livestock). In Benin, local dairy production was not developed and milk cows were maintained in a traditional farming system by the "*Peulh*". Dairy-by products were thus mainly imported (Kees, 1996). It is known all over the country that dairy farming has always been part of the life of the *Fulani* or *Peulh* society (Akuesson, 2001; Bosso, 2006; Nyiransabimana, 2005; Ogodja, 1988; Personal observation, 2006).

Although dairy production was maintained at a low level, some studies were published by Akuesson, (2001) and Ogodja, (1988). Since 1994, the devaluation of the CFA doubled the prices of imported products and the population became more interested by the local products. In 1994, these imports were about 6 804 tons for a value of 1.5 billion CFA and 9.529 tons were imported in 1997 for a value of 7.5 billion CFA. In 2003 milk and dairy product imports reached the value of 20 billion CFA. The volume of the dairy products imported induces a serious challenge to balance of payments in Benin (FAO/TCP, 2005; MDR/DE/DRH/DIFOV-MEN/UNB/FSA/CIS-CSR, 1994; Rakotoarijaona, 2005).

Although dairy production is not developed in Benin, some efforts have been made and a few programs have been implemented by the Beninese government, to improve dairy production systems and satisfy the internal demands and needs (MEHU, 2007). These programs are as follows:

- In 1994: The "*Programme d'appui à l'amélioration de la production laitière au Bénin "*, which was supposed to start in May 1994 and end in September 2000. The main activities were artificial insemination and the genetic characterization of *Borgou* breeds and *Lagoon* breeds; added to these activities, the formation of associations for farmers and the breeders. This program was handled by the PDPA/DE/MDR and the UNB (MDR/DE/DRH/DIFOV-MEN/UNB/FSA/CIA – CS, 1994).

- From 2002 until now: The PDPE /DE/MAEP Program aims at the genetic improvement of dairy performance for the local breed *Borgou* (DE, 2003, 2004, 2005; MAEP/DE/PDE III, 2004; MAEP/DE/PDE III, 2005).

- In 2004 the "*Bureau d'études CIENI*" evaluated the feasibility of using goats and sheep for milk production with the "*Projet de Développement de la production laitière et de l'élevage des petits ruminants (DPLEPR)*". Thus small ruminants are progressively involved in agricultural strategies related to dairy production (CIENI SA, 2004).

- 2005-2006: A joint agreement Benin /FAO in April 2005 was signed for the commercialisation of milk and traditional cheese production using the « *Programme d'appui a l'amélioration de la collecte, de la transformation et de la commercialisation du lait, du wagachi et d'autres produits laitiers* » (FAO/TCP, 2005).

According to an economic perspective done between 2000 and 2005, the values below explain the increase in the internal demand for dairy products (Akuesson, 2001).

- Livestock growth rate was 3,3% per year.
- Urban population growth rate was 4,5% per year.
- Average national dairy production of 1,7L per cow per year remained the same between 2000 and 2005.
- Traditional cheese production of 3000 tons per year remained the same between 2000 and 2005.
- Importations of milk and milk products (13879 tons per year) also remained the same.

2.2.3.2 Livestock and dairy farming systems in Benin

- Characteristics of livestock

Livestock is an important traditional activity in Benin. Farming with large ruminants is the second most important source of income for the rural community after cotton, particularly in the northern part of the country. Livestock represents 4% of the National GDP and Benin has 1.487.000 heads of cattle with about 70% in the departments of Borgou and Alibori (CIENI SA, 2004).

In Benin there are no genuine dairy production or husbandry systems. Livestock farming is generally traditional, extensive and multi-purpose. Breeds are represented by Taurin breeds (*Lagoon, Borgou* and *Somba*) and zebu breeds (*Mbororo, Goudali* and *white Fulani)* (Nyiransabimana, 2005).

The Beninese Government has been, promoting more productive livestock systems, particularly dairy production. This strategy follows the Regional West African sub-Saharan global strategy (Houndonougbo, 2002; MAEP, 2004; MDR/UNB/FSA, 1994). As some authors have explained, this strategy aims to diversify agricultural production, to replace dairy product imports by national dairy production, and to reduce the loss of currencies (Brumby & Gryseels, 1984; Delgado, *et al.,* 1999; Matthewman & Chabeuf, 1993; Mbogoh, 1984;).

Livestock systems have evolved and traditional farms are found in the central and the southern areas of the country. Several studies have contributed to the implementation and the improvement of dairy production (Akuesson, 2001; CIENI SA, 2004; MDR/DE/DRH/DIFOV-MEN/UNB/FSA/CIA-CSR, 1994; Nyiransabimana, 2005)

- Dairy products

Dairy products in Benin are represented by milk, sour milk, traditional cheese and butter. In 2004, the volume of meat and milk production was respectively 30.000 and 40.000 tons (DE, 2003, 2004 & 2005; CIENI SA, 2004).

- Breeding systems

Four breeding systems related to dairy production co-exist in Benin. These are transhumance, agro-pastoral and sedentary. They are discussed in more detail below (DE, 2003, 2004 & 2005; CIENI SA, 2004).

  - Transhumance:

Transhumance is located in the northern part of the country. It mainly concerns cattle herds of 60 to 80 head. Many herds congregate and move together. This migrant type of farming is in force in the more arid areas during the dry season (from October to May) and is extensive and traditional. Herders move the animals (cattle, sheep and goats) in search of pasture and water. The duration and distance of the migration varies from less than 100 to over 1000 km. Sometimes these farmers are nomads from as far away as Niger, Burkina Faso or Mali.

  - The agro-pastoral system:

In the dry season, livestock is associated with crop farming in the agro-pastoral system. Animals are put into a different camp every night, utilizing rotation so the crops are enriched with the animals manure while the crop-residues and agro industrial by-products are added to animals' food. This system is also found in the northern areas of Benin.

  - Sedentary system:

Crop farming is the main activity in the sedentary farming systems. The cattle are sent out to graze on communal grazing and brought in at night. There is no camp rotation to fertilize the croplands with animal manure. This system is widespread in the humid areas, where water resources and pasture are abundant during the whole year.

  - The modern system

In Benin this system concerns mainly small ruminants, and a small number of cattle. It is established mainly on the State farms and private farms. Nutrition of cattle is balanced and the health care is strengthened. There is no communal grazing and there is a secure boundary. Biosecurity and records are a priority. This system is similar to farms in Europe.

- Animal health

Basic and primary animal health care is well implemented in Benin. However livestock health is still threatened every year by infectious and parasitic diseases as well as some important tropical diseases. Dermatophilosis, brucellosis, tuberculosis, mastitis, foot and mouth disease and tryponosomiasis are endemic in Benin and some cases of anthrax exist (DE, 2003, 2004 & 2005)

The veterinary services are committed to the organisation of the supply and the distribution of veterinary drugs and other livestock inputs. However the necessary synergy between the private sector, rural organisations and the state veterinarians has not yet been implemented.

- Nutrition

Natural pastures are the main component of ruminant feeds in Benin. The quality and the quantity of forage is good during the rainy season, but during the dry season pasture is scarce and the nutritional quality of the grass is low. This situation is one of the causes of transhumance in the country. Implementing good management of natural pasture becomes a serious problem because of the movement of livestock and the fact that the herders take no responsibility for maintaining the pastures. Crops and agro-industrial residues are frequently not well utilised because the industrial sector is not developed. To solve this problem, grazing and forage farming systems have become popular amongst those farmers interested in breeding cattle, in the traditional breeding areas (FAO/CAF, 2005; Von Massow, 1989; Personal observation, 2006).

2.3 Dairy production in SA and in Benin

2.3.1 Dairy production in SA

The production of milk from cattle was initially part of a traditional farming system in SA and many breeds used were dual purpose or indigenous, rather than dairy breeds. However, marketing of dairy production as a separate farming system occurred after the Second World War, because milk and milk products were needed to feed the expanding urban populations. Currently, commercial cattle farming are divided into stock farming and dairy farming systems (Maree &

Casey, 1993; Steyn, 1999). Dairy farming is practiced throughout SA, with the highest concentration of dairy farms in the eastern and northern Free State, North West, the KwaZulu-Natal Midlands, the Eastern and Western Cape, the Gauteng metropolitan area, and the southern parts of Mpumalanga. Commercial dairies are mainly found near the metropolitan areas and along the coast, particularly the Eastern Cape seaboard. The dairy breeds are: Holstein, Jersey, Guernsey and Ayrshire.

According to the National Department of Agriculture, 4300 milk producers and 60 000 farm workers are directly employed by the dairy industry and 40 000 people are indirectly involved. Milk production for 2003/4 was estimated at 2000Ml (NDA, 2003, 2005). Different companies such as the Taurus Livestock Improvement Co-operative in Irene, Gauteng, provide the dairy industry with thousands of units of semen annually for use in artificial insemination (NDA, 2006; SA Government, 2007).

SA has a deregulated dairy processing industry. The milk price was deregulated in 1983, resulting in lower prices, but industry regulations continued to enforce strict health precautions. Trends in annual per capita production of milk have decreased over time, reflecting the changing profitability of dairy farming (SA Online, 2006).Over the period 1995 -2003, exports of dairy products ranged between 87,000 and 232,000 tons (in milk equivalents). In 2002 the production of milk was higher than consumption, by between 2 and 2.5 million metric tons. However in 2003 imports were 162,000 tons while exports were 87,000 tons (Collins, 2004; FAOSTAT, 2005 (c) & (d)). The annual dairy production in SA is shown in Table 2.6 below:

<u>Table 2. 6</u>: Evolution of bovine livestock and national dairy production in SA*.

Years / Number	1999	2000	2001	2002	2003	2004	2005	2006	2007
Cattle nos. (,000,000)	13.8	13.6	13.5	13.6	13.5	13.5	13.8	-	-
Milk production total (x1000Mt)	2667	2540	2759	2685	2642	2552 2,220 (1)	2552 2,320 (1)	2,050 2,420 (1)	2.370 (1)
Import of Milk (x 1000 Mt)(1)	120	199	114	153	161	80	140	149	160
Export of milk (x 1000 Mt) (1)	325	64	126	216	91	106	64	74	12

*Source: FAOSTAT, 2005 (c) and (d); MPO Personal communication; Jas Wasserman, 2007

2.3.2 Dairy production in Benin

Although the *Borgou* breeds are not basically dairy breeds they are the best producers of milk in Benin with 2, 5 litres per day per cow in the traditional system and 4 litres in the improved system (Ahomlanto & Lhoste, 2005; Ogodja,1988;).

In Benin, milk and dairy products play a major socio-economical role in the different groups of the population. They have been a source of economic gain for the pastoral and agro-pastoral families. Women in these societies are mainly involved in the management of milk and dairy products (Kees, 1996).

The dairy sector is entirely managed by the community of the *Peulh* who consume 53% of the local production and sell the remainder. However, although the traditional collection nets are well-organised and the livestock numbers are increasing, infrastructure and equipment are deficient, so the norms for dairy product quality are not well defined or monitored. The dairy local net has a limited volume and dairy product consumption requirements above those filled by local producers are met by imported dairy products (FAO/ TCP, 2005; Rakotoarijaona, 2005).

The production of milk and dairy products is relatively low in Benin in comparison to demand and the country imports large quantities of dairy products (IFCN, 2005). In 2002, Benin imported 6.922 tons of dairy products representing 2,3 billion F CFA, the major part of which was re-exported to Nigeria and the hinterland countries. This is because the port at *Cotonou* is well organized for import and there is a good road network to the neighboring countries (Houndonougbo, 2000).

In 2003, milk and dairy products imports reached the value of 20 billion FCFA. The volume of the dairy products imports induces a loss of currency in Benin (FAO/TCP, 2005; Rakotoarijaona, 2005, MAEP/DE/PDE III, 2005).

The total consumption of milk and dairy products in Benin, which is about 20 L/person/ year, is very low compared to the mean consumption in developing countries (34 L /person/year) and the normal consumption of 50L /person per year advised by WHO (WHO, 2007).

Since 2000, a special project to improve dairy production has been set up. Some exotic breeds have been introduced into Benin to improve bovine dairy production. Good dairy farming practices have then been implemented on the farms concerned (MAEP/DE/PDE III, 2004; UNB /FSA /Coopération française /GRET, 2006). Meanwhile, the consumer demand, the imports of dairy products and the dairy by-products resulting from the manufacture of yoghurt have been increasing year by year. The number of dairy factories has shown an upward trend since 1972 (MAEP/DE/PDE III, 2003).

Milk collection and storage is a severe constraint to the marketing of dairy products in the country. A joint program by the Government of Benin and the FAO (Food and Agriculture Organization of the United Nations) started in 2005. This program specifically aims at the improvement of milk technology by the use of Lactoperoxydase (Ahomlanto & Lhoste, 2000; FAO/TCP, 2005).

There are no specific local dairy breeds of sheep and goats in Benin. Between 2003 and 2004, some exotic goats (Alpine goats) were introduced into Benin for dairy production (DE/PACE, 2004). According to many authors (Nyransabimana, 2005), about 15% of bovine livestock in West Africa and particularly in Benin are milked. In 1997 milk production was 62 million liters and 82 million liters by 2004 (DE/PACE, 2004). Table 2.7 below shows the evolution of bovine livestock and national dairy production in Benin.

<u>Table 2.7</u>: Evolution of bovine livestock and national dairy production in Benin*

Years	1999	2000	2001	2002	2003	2004
Number of cattle (1)	1 439 652	1 487 157	1 584 384	1 635 056	1 684 108	1 717 900
Number of cows (1)	532 671	550 248	589 910	604 971	620 095	635 623
Milk production (kg)(1) ℓ (1)	71 324 679 kg 69 247 261 ℓ	73 678 220 kg 71 532 252 ℓ	78 988 981kg 76 688 331 ℓ	81 005 580 kg 78 646 194 ℓ	8 330 699 kg 80 612 329 ℓ	85 109 920 kg 82 630 990 ℓ
Import of milk (kg) (2)	10 882 825	9 645 832	16 386 117	15 786 788	13 583 768	

*Source 1: DE/PACE, 2004 ; INSAE, 2004 & 2005

2.4 Legislation in regard to milk and dairy products in SA and in Benin

National and International regulations related to dairy issues and water pollution issues in both countries are summarized in Appendix A (Tables 2.9, 2.10 and 2.11). Other national or international legislations may also be relevant, although it is not specific to dairy issues or water issues (Table 2.12).

2.4.1 Laws and regulations related to milk and dairy products in SA

In SA, commercial dairy systems and dairy production are strictly the result of a well organized private sector, aware of the regulations. This sector works closely with governmental institutions represented at the national, regional and local level. These institutions are committed to the monitoring and quality control of milk production. Details on the organization within the dairy sector are given in section 2.3.1.1. National laws and regulations are strongly implemented and most of them follow the International regulations because the country is actively involved in importation and exportation of dairy products. SA has partnerships with some international organizations using the HACCP certification system. Since 2003, the country has implemented boards of standards for quality management systems like ISO 9000 for food quality and HACCP systems (USDA /US Embassy, 2003).

2.4.1.1 The Institutions

The regulations related to livestock and dairying is essentially managed by the National Department of Agriculture and Land Affairs (NDA) and the National Department of Health (DOH). Both government institutions have close ties with provincial departments, para-statal institutions and para-public services, Non profit organizations (NPOs) and non–governmental organizations (NGOs), regional and international organizations. Dairy farms, industries, and other associations are part of the private sector. The National Department of Trade and Industries (DTI) is concerned with all import/export issues related to milk dairy products and the local distribution networks for milk and milk products in SA.

There is a strong relationship between the farmers, manufacturers, dairy industries, commercial dairies and the Government through several national associations like the Dairy Standards Agency (DSA), Milk SA, the Milk Producers Organization (MPO) and SA Milk Processors and Retailers Organization (SAMPRO) (SA Government, 2007).

The DSA is a private organization that makes the junction between the SA government and the dairy producers and processors, in order to ensure dairy products quality and standardization. This institution is formally acknowledged by the organized dairy industry (Milk SA, MPO, and SAMPRO), the organized consumers (the SA National Consumers Union), the retailing sector and the different government institutions responsible for the determination and the reinforcement of the legal standards (Jordan & Kraamwinkel, 2007).

According to Ina Jordan, managing director and Alwyn Kraamwinkel, chairperson of the Board of Directors of the Agency, this institution is constituted under:

"*Section 21 of the Company Act of SA, and was established by the dairy industry to be an expert and objective body that promotes the improvement and the quality of milk and other dairy products; -the monitoring of products for compliance with the legal standards in respect of milk and other dairy products; and regular communication with authorities as the official Agency of the dairy industry regarding food safety and quality issues*" (DSA, 2007; Jordan & Kraamwinkel, 2007).

In addition to the international organizations of certification in partnership with the country, two national institutions exist to implement food quality standardization:

- The Perishable Products Exports control Boards (PPECB)
- SA Bureau of Standards (SABS) is in charge of the review of the Codes of Practice (USDA/US Embassy, 2003).

SA is also a member of the most important international organizations namely, OIE, WHO, FAO, the Codex Alimentarius Commission, IDF and WTO (Savage, 1979; WTO, 2006). The country is bound by the relevant International Agreements and Regulations. Technological, microbiological and chemical aspects are monitored by different laboratories, mainly under the auspices of the DSA, that play an important role in the control of the quality of dairy products in line with these international standards.

2.4.1.2 Laws and regulations

SA is a signatory of numerous international multilateral agreements and conventions with FAO, WHO, OIE, WTO, and CGIAR. Bilateral agreements exist with the European Union[1],[2] and the

[1] www.southafrica.info/doing_business/sa_trade/agreements/trade_europe.htm

USA[37]. National, provincial and communal legislation exists (Fedics, 2004). In SA, the milk price has been deregulated. There are few specific regulations about dairy by-products that are related to direct effects on human health and animal health (Casey & Meyer, 2001; National Government SA, 1996).

Biodiversity, economic impacts or other indirect effects of water pollution by dairy are not completely and clearly included in legislation (National Government S.A., 1998).

Three acts related to milk and dairy products regulations have been passed by the Parliament:

1. The Foodstuffs, Cosmetics, and Disinfectants Act, 1972 (Act 54 of 1972) has been revised for milk and milk derived products and is administrated by the Department of Health and delegated to the local authorities of Health Departments (DOH, 2003). Regulations pertaining to milk and dairy products are:
   - Government Notice No 908 of 27 June 2003, related to the Schedule of the regulations relating to the application of the Hazard Analysis and Critical Control Point System (HACCP) (DOH, 2006).
   - The audit format is also based on Regulation 1256, Regulation1555, Regulation 918 and Regulation SABS 049.

2. The Health Act, 1977 (Act 63 of 1977) has been reviewed (Act 61 of 2003) and is also administrated by the Department of Health. The following regulations are related to dairy and dairy products:

   - Government Notice R 1256 of 27 June 1986 on the Regulations relating to milking sheds and the transport of milk is the regulation related to milk issues.
   - Government notice R 1555 of 21 Nov 1997 on the regulation related to milk and dairy products and Government Notice No R.1809 of 3 July 1992, as amended is the regulation governing Maximum Limits for Veterinary Medicine and Stock Remedy Residues that may be present in Foodstuffs, are the key by laws of this Act. (DPS/Faculty of Veterinary Sciences/ PHE 500, 2007)

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[2] www.southafrica.info/doing_business/sa_trade/agreements/trade_europe.htm
[3] www.usaid.gov/our_work/environment/climate/policies_prog/joint_statements.html.

- Regulation 918 of 1999 and Regulation 908 of 27 June 2003, Regulation SANS 10049 (Regulation SABS 049 are related o HACCP[4]

3. The Agricultural Products Standards Act, 1990, that amends many sections of the Marketing Act (Act 59 of 1968), is administrated by the Directorate of Plant and Quality control of the National Department of Agriculture. Applicable regulations:

   - Government notice R1469 of 26 August 1994 concerns the Regulations Regarding Dairy Products and Imitation Dairy Products.

Some of the laws and regulations which are not specific to dairy issues are also utilized by the National Department of Agriculture and Veterinary Services to control aspects of milk hygiene and effluent from dairy farms (NDA, 2003 & 2005; DOH, 2003, 2005 & 2006).

The Dairy Standards Agency (DSA) is currently developing a "Code of Practice" (COP) for the dairy industry which covers the entire spectrum of practices, from farm - to fork (Jordan & Kraamwinkel, 2007). This COP will include the following:

At farm level

Good Agricultural Practice (GAP)
Good veterinary Practice (GVP)
Good Hygiene Practice (GHP)

At factory level

Good Manufacturing practice (GMP)
Good Hygiene Practice (GHP)
Good laboratory Practice (GLP)
Good Distribution Practice (GDP)
A DSA Milk classification system has been being implemented for better communication of the results of the scientific tests required by law; this system is currently being systematically applied to raw milk.

[4] www.foodhygiene.co.za/about_haccp.htm -

2.4.2 Laws and regulations related to milk and dairy products in Benin

In Benin, as we have seen above, dairy production is mainly run by a private traditional society using traditional rules and customs. Until 1990, professional or governmental institutions were only involved in situations of animal health crises, although they were represented at national, regional and local level.

The consumption of imported milk and milk products is higher than that of traditional products in Benin. However, as many studies have showed, a greater interest is emerging in traditional cheese (“*wagashi”)*. Since the rising prices for imported milk, dairy farming systems and dairy production management has evolved with the help of the Government and some private professionals. Breeders’ associations are now frequently in consultation with public institutions. Three governmental institutions are primarily in charge of dairy issues: the Ministry of Agriculture Livestock and Fisheries, the Ministry of Health and the Ministry of Trade. Other departments are involved at a second level (MAEP, 2004; MCIPE, 2004; MSP, 2005).

Specific regulations connected to local dairy products are almost non-existent. The regulations in use are mainly connected with livestock in general, as well as commercialization or the quality of imported milk and milk products. Traditional key role - players are thus not yet aware of the current norms and regulations and GAP is not implemented in traditional farms.

The legislation generally in force in Benin is linked to African or international rules, managed by International organizations namely OIE, FAO, WHO, WTO, ISO and Codex Alimentarius. However, since 2000, some efforts have been made at the regional level to improve GAP, Good Hygiene Practices and GMP in the traditional milk chain. Benin is represented in various regional workshops; some short training courses related to HACCP and GAP has been organized by the FAO, WHO/OMS, and UEMOA/WAEMU. A few local yoghurt factories have been implementing GHP, GMP and HACCP systems for hygiene monitoring and control (DE, 2003, 2004 & 2005).

2.4.2.1 The institutions in Benin

- National institutions of livestock and dairying

The government institutions in charge of the management of dairy products work with private institutions and Non-Government Organisation (NGOs) are as follows:

  - The Ministry of Agriculture, Livestock and Fisheries (MAEP).

The Directorate of Livestock (DE), the National Agricultural Research Institute (INRAB), the Regional Services of Animal Productions and Health, the Directorate of Nutrition and Applied Alimentation are the four institutions concerned by dairy issues (MAEP, 2004; MAEP/DE/PDE III, 2004(a) & (b), 2005)

- The Ministry of Industries, Trade Promotion of Employment with its institutions.
  The Directorate of External trade is in charge of all aspects of import-export.
  The CEBENOR is in charge of aspects of standardization, accreditation and certification of national products and BIVAC International. BIVAC is actually a private society responsible for examining goods intended for direct consumption and monitoring exemptions (CEBENOR, 2007).

Benin does not export any dairy products; but commercialization of dairy products is regulated by some laws. These generally follow international regulations and norms elaborated by the concerned sub - regional and regional organizations (ECOWAS, 2006 (b); MICPE, 2005; WTO, 2006). These include:

- The Ministry of Public Health is concerned by all the aspects of human health related to the consumption of dairy products (MSP, 2005; OIE, 2007).

- The Ministry of High Education and Scientific Research through specific institutions of research in the Universities as well as other national and international institutions is interested by the research aspects.

- Regional institutions

  Benin has signed Bilateral and Multilateral Institutional Agreements with regional institutions committed to the development of livestock. Few regulations in force are directly related to dairy products. The institutions concerned are: the Conseil de l'Entente, the CEBV (Meat and Livestock Economic Community), the CILSS (International Center for fight against drought in the Sahel), the CIRDES (Inter Regional Center for the Development of Livestock in Sub-humid area), UEMOA (Western Africa Economic and

Financial Union), CEDEAO/ECOWAS (Communauté Economique des Etats de l'Afrique de l'Ouest/ Economic Community of Western Africa States), CIPEA (International Center for Livestock in Africa), ILRI (International Livestock Research Institute) and Project PACE (Pan African Campaign for the Epizooties).

- International organizations

  Government institutions are connected by many agreements to international organizations concerned with dairy by-products issues. These organizations are:

  - WTO (World Trade Organization) concerned by food trade issues.
  - FAO (Food and Agriculture Organization) concerned by the food safety, food hygiene and food quality issues.
  - OIE (Office International des Epizooties) which is the World Organization for animal health and in this case, zoonosis and food borne diseases.
  - WHO (World Health Organization) committed to human health issues.

2.4. 2. 2 Laws and regulations

Specific legislation linking dairy by-products and water pollution are scarce. The regulations generally in force in Benin are linked to African or international legislation, managed by the following international organizations: OIE, FAO, WHO, WTO, ISO and Codex Alimentarius standards). Apart from some data from the Ministry of Agriculture Livestock and Fisheries, and the Ministry of Public Health, the majority of the information available is about the importation of dairy by-products and can be found in the ministry in charge of Trade and Industry.

Table 2.10 in Appendix 1, contains the available non-specific regulations on food of animal origin, in force in Benin, which are applicable to dairy production.

2.5. Legislation in regard to water pollution in SA and in Benin

2.5.1 Laws and regulations in regard to water pollution in SA

In SA, regulations regarding water pollution are well managed because environmental issues are important for everyone in the country. National rules and regulations are linked to the international standards. These regulations are handled and monitored by the Department of Environmental

Affairs and Tourism (DEAT) and the Department of Water Affairs and Forestry (DWAF). However, water issues are extremely important in the agricultural sector. Thus DOA is also involved in the management of water resources in SA. The actions of these three Departments overlap with one another within the same framework (Burger, 2005 & 2006).

Although there appears to be no specific legislation linking water protection and dairy production, since 1999, the DEAT and DWAF have developed a policy on pollution prevention, waste minimization, impact control and remediation through the implementation of a project called the Waste Discharge System (WDCS). This strategic action plan has started to apply the Polluter Pays Principle and it is likely that it would be applied to dairy producers as well (SA Government, 2007).

2.5.1.1 Overview of environment and water pollution in SA

- Environmental issues

SA has many natural resources, but some severe environmental problems threaten this wealth. Environmental issues are mainly related to droughts and water scarcity, soil erosion and land degradation, air pollution and acid rains (Country Studies US, 2006; Crosby, 2004; EIA, 2003 & 2006). Degradation is mainly caused by overgrazing, over-cultivating and settlement patterns in overcrowded areas. Industrial wastes and pollutants, acid and chemical from the mining industry cause environmental damages. Agriculture and commercial farming practices suffer from this negative impact on the environment. Land near mining operation areas has often been considered as “sterile or too contaminated for farming”. This situation considerably reduces the area of land available for farming (EIA, 2003 & 2006).

Air pollution and marine pollution are also among the environmental challenges that the country faces. Rapid industrialization and manufacturing for export are important issues in development strategy in SA (EIA, 2003 & 2006).

Serious soil erosion is caused by several SA's rivers that have an unusually high rate of runoff. In addition, numerous dams have been built for water consumption needs and irrigation for agriculture. Almost 50% of SA's water is used for agricultural purposes (Country Studies US, 2006).

In 1997 the Department of Environmental Affairs and Tourism developed the White Paper for Environmental Management and in 1998; the National Environmental Management Act consolidated the legislation. National standards have since been established; however financial issues are the major constraints that limit implementation (Country Studies US, 2006).

The most important factor limiting agricultural production is the availability of water. Rainfall is distributed unequally throughout the country. Water scarcity is caused not only by the periodicity of South African rivers, but also by long periods of drought (Crosby, 2004). Indeed, SA is situated in an arid to semi-arid sub-tropical area. Apart from marine pollution, fresh water pollution is not yet considered as a critical environmental problem in SA. However, legislation has been implemented to protect water resources and to guarantee the availability of water (AQUASTAT, 2005, (a), (b); Meyer *et al.,* 1991).

- Water resources, uses, management and water pollution

As mentioned above, SA is situated in a dry, mainly semi-arid to arid area and water resources are scarce and extremely limited. This scarcity is mainly due to geographical aspects. According to rainfall, three climate zones exist in SA (AQUASTAT, 2005(a), (b)).

- The eastern part with an annual precipitation of 1200 mm.
- The central and the western parts of the great plateau are semi-arid to arid and characterized by an annual precipitation of 200 to 500 mm.
- The Cape fold mountains and the area between them with rainfall varying from 300mm to more than 900mm.

The average annual rainfall is 450 to 495 mm, ranging from less than 100 mm/year in the western deserts to about 1 200 mm/year in the eastern part of the country. Only 35 percent of the country has a precipitation of 500 mm or more, 44 percent a precipitation of 200-500 mm and 21 percent a precipitation of less than 200 mm. Therefore, 65 percent of the country does not receive enough rainfall for successful rain-fed crop production and is used as grazing land (AQUASTAT, 2005 (a), (b); Country Studies US, 2006; University of Western Cape, 2006).

The total annual surface runoff is estimated at 48.2 km^3, or approximately 9 percent of annual rainfall. However, much of the total runoff volume is lost through flood spillage and evaporation, so that in 2000 the available yield was estimated at 13.9 km^3 only per year. The total dam capacity is estimated at 28.5 km^3. About 4.8 km^3 of groundwater is produced per year, of which an estimated 3 km^3 is, in turn, drained by the rivers. Although groundwater is limited due to the geology of the country and large porous aquifers occur only in a few areas, it is extensively utilized in the rural and more arid areas; ground water plays a pivotal role in rural areas and few aquifers can be used on a large scale. Most of the major aquifer systems contain potable quality water, provided that they are not polluted by emerging industries or increased population density of humans or animals (this latter includes dairy production and processing). In 2002, 98 % of the urban and 73 % of the rural population were using improved drinking water sources, amounting to a national coverage of 87%. Less than half (45 %) of South African households had a tap for water inside the dwelling. Groundwater is utilized for human consumption (including water used in food production as well as potable drinking water) and will increase. This could become a problem, especially in the western part of the country which lacks perennial rivers (AQUASTAT, 2005(a)).

Surface and groundwater resources are used in different sectors of the economy. 72% of water resources are used by the Agricultural sector, 17% for domestic purpose and 11% by the industrial sector (AQUASTAT, 2005(a); Country Studies US, 2006; EIA, 2003). Available yields from these resources are estimated at 1 km^3/year in 2000. Estimation of still undeveloped potential of resource shows that the yield from surface water could be increased by approximately 5.6 km^3 per year by the year 2025. Potential also still exists for further groundwater development, although on a smaller scale (AQUASTAT, 2005 (a), (b)).

Irrigation and drainage systems play an important role in SA economy and society. But due to the present high cost of irrigation, a large sector of the irrigation community is no longer advised about the latest developments in irrigation technology (AQUASTAT, 2005, (a), (b))

It is estimated that between 1990 and 2010, water demand will increase annually by 1.5 %, ranging from 3.5 % for urban and industrial use to 1 % for irrigation (AQUASTAT, 2005 (a), (b)).

In SA many efforts have been made to solve the problem of water scarcity and improve water management. These efforts include policies, legislation and implementation of projects. However, the development of some economic sectors threatens the quality of water resources. This is the case for farming, mining and some industrial sectors (Burger 2005 & 2006; EIA, 2003).

Water resource management is under Water Services, which have developed a National Water Strategy. The monitoring of water resources highlights some major stressors:

- Water abstraction, causing the destruction of riparian vegetable and the growth of alien species,
- Eutrophication due to chemical pollutants:

In addition, they monitor water resources and aim at the improvement of water quality by various programs of water purification. Thus water pollution issues are regarded as a serious constraint to successful water resource management. Water quality is regularly monitored in the rivers and in the dams; actions have been taken to improve water quality, but data on water pollution due to livestock farming systems and specifically dairy, do not exist. Indeed the agricultural sector is concerned in the problems that are arising in the control of water pollution in SA (AQUASTAT 2005 (a) & (b); Braden & Lovejoy, 1990).

In most cases, waste management is at a very low level or absent in informal settlements that develop near cities. Pollution of water resources results not only in the local population becoming threatened by waterborne diseases, but can also be aggravated by the livestock belonging to these informal dwellers, this includes cattle used for milk production (Prozesky *et al.,*2004*)*.

2.5.1.2 The institutions in SA (water pollution legislation)

The following institutions are involved in containing and controlling water pollution in SA:

- The DEAT and DWAF are directly concerned with laws and regulations related to the environment and water pollution. Water issues are also extremely important in the Agricultural sector. The DEAT is charge of environmental quality and protection and works closely with the DOA through the Directorate of Pollution and Waste Management, to master water pollution. Environmental impact assessments (EIA) are handled by the private sector but coordinated by the DEAT (EIA, 2006). Environmental Affairs are also in government structures at provincial, regional and local level (DWAF, 1999 and 2006 (a) & (b); Thornton & Beckwith, 1997),

- The Ministry of Forestry and Water Affairs, supported by DWAF is responsible for the implementation of the Water Act. The DWAF acts against polluters, if they can be identified. In addition to direct pollution, irrigation, drainage, and return flow increase the salt content of rivers and even underground water. Another core function of DWAF is to ensure equitable access to water and sanitation. Within DWAF, the Directorate of Water Quality Management and the various Regional Offices are jointly responsible for the governance of Water Quality in SA (Burger, 2006; DWAF, 1999).

- The Ministry of Agriculture, through the National DoA and the Provincial Departments of Agriculture, Conservation and the Environment (DACE), is responsible for agricultural extension with the aim of improving the efficiency of irrigation and water use. The Department of Land Affairs (DLA) is responsible for the settlement of new farmers and works in collaboration with the DOA, DACE and DWAF.

- Water management has being shifted to the local level through was Water Users Associations (WUS) and pilot studies related to the above implementation are in process (Burger, 2005, 2006; Casey *et al.*, 1998; Casey & Meyer, 2001).

2.5.1.3 Laws and regulations in SA that are linked to international legislation

These are discussed under two sections: environmental issues and water quality issues.

- <u>Environmental issues</u>

The DEAT has developed a series of information documents on integrated environmental management. Current legislation is aligned with the Constitution of the Republic of SA. The basic legislation which is followed is contained in the documents below:

- Agenda 21 adopted in 1992 by the *United Nations General Assembly Conference on Environment and Development* is considered as the main regulation for the global strategy for sustainable development.

- o National Environmental Management Act, 1998 (Act 107 and 108 of 1998) (SA Government, 2007). This Act sets principles for effective management of the environment and is applicable at national provincial and local level. It includes:

  - Environmental Implementation Plans (EIPs) and Environmental Management Plans, provide a legal framework for environmental development (EIA, 2003).

  - Regulations also provide for Environmental Impact Assessments.

  - The Implementation Plan includes programmes to deliver water, energy, healthcare, agricultural development, and a better environment for the poor; it targets the reduction of poverty and protection of the environment.

- o In terms of the amendments to the Environmental Conservation Act (Act 73 of 1989), the control by the Government of products, even before they become waste, is also regulated. (SA Government, 2007).

- Water quality issues

The Constitution of the Republic of SA, 1996 (Act No. 108 of 1996) regulates the management of Water Resources as an exclusive national competency. Thus, the National Water Act (Act No. 36 of 1998) mandates the Ministry of Water Affairs and Forestry to ensure that water is protected, used, developed, conserved and managed in a sustainable and equitable way for the benefit of everyone (DWAF, 2006[5]; National Government S.A, 1998).

National rules and regulations are linked to the international ones. These regulations are handled and monitored by DEAT and DWAF. There is no specific legislation about water pollution issues due to dairy production and processes; however the general legislation covers for pollution by agricultural systems - thus including dairy production indirectly. The National Water Policy of 1997, and the National Water Act (NWA) of 1998(36/1998) are the basic policy texts for water regulation implemented by the DWAF. The relevant legislation currently in force in SA is summarised below (DWAF, 2006; SA Government, 2007).

[5] http://www.dwaf.gov.za/Dir_WQM /index.htm.

- NWA provides for integrated management, sustainable use and devolution to catchments of surface and groundwater, at local level. It has a supporting role through promotion of awareness, information, provision and capacity-building. The objectives are the control of the use and the protection of water resources from over-exploitation and pollution. The Act also aims an equitable access to water resources; the DWAF is responsible to gathering the necessary information for the optimization of the management of water resources. One of the important tools of the Water Act is the registration of water-use. The Water Act of 1998 determines that "*all water use, with the exception of reasonable domestic use, home garden use and stock water requirements, must be licensed. Substantial volumes from industrial and urban development are returned to streams and are available for reuse*" *(*DWAF, 2006; SA, 2007).
- The Water Services Act of 1997 (108/1997)[6] , together with the Environment Conservation Act (73 of 1989) provides a framework for the collection and publication of information on water services. It should be considered as one of the more powerful regulatory tools available to the SA National Government. In terms of this Act, *"Water-Development plans according to the framework of Integrated Development Plans required by municipal legislation are produced by water services authorities. The water boards are also regulated through a comprehensive framework"* (DWAF, 2006).
- The Free Basic Water (FBW) Policy was officially launched in July 2001.
- The Strategic Framework for Water Services (SFWS) approved by Cabinet in September 2003, was previously referred to as the White Paper on Water Services[7] (DWAF, 2006; SA Government, 2007).It is a confirmation of all policy changes and aims at a framework for its implementation in water resources and services as a whole. Before a license can be issued, a complete EIA of the rivers and streams concerned is conducted. With the implementation of the National Pricing Strategy for Raw Water, which began in 2002, water users are bound to pay as far as possible, the costs of the management of water resources and water-supply infrastructure.
- The Mineral Act (50/1991), Prevention of Atmospheric Pollution Act (45/19650) and the Local Government Transition Act (209/1993) can sometimes be useful for the

[6] http://www.info.gov.za/gazette/acts/1997/a108-97.pdf)
[7] http://www..dwaf.gov.za/Documents/Policies/nwpwp.pdf

application of the regulation related to the dairy producers located in urban and pair urban areas. (SA Government, 2007).

- Legislation relating to environment and water issues in SA is summarized in Tables 2.12 and 2.13 in Appendix 3.

2.5.2 Laws and regulations with regard to water pollution in Benin

The climate and livestock-environment issues in Benin have been described on the FAOSTAT website (FAOSTAT, 2005 (a); FAOSTAT, 2005(b)).

2.5.2.1 Overview of environment and water issues in Benin

Until 1990, the Ministry of Mines, Energy and Hydraulics (MMEH), handled water resource management and pollution regulations. The Ministry was responsible for ensuring the availability of drinking water to the population, while the Ministry of Public Health was involved in water quality control. Each of them had a specific role and different activities were handled separately. The other ministries, mainly the Ministry in charge of Agriculture, managed the users of the water resources in the respective fields (humans, animals, crops and horticulture). However; livestock issues were not included in the sectoral strategy. There were very few regulations on either dairy production or water pollution (Onibon *et al.*, 2006; GWP/WAWP; 2006).

After 1990, there was a progressive awareness of the importance of water pollution associated with dairy production and, because the introduction of commercial dairy farming was being considered within the strategy for the livestock sector (MAEP/DE, 2003; MAEP/ DE/PDE, 2004 (a), (b)).

The Beninese Agency for the Environment (ABE), located in the Ministry of the Environment, has developed training and workshops related to environmental policies, environmental risk assessment, environment audits, and other risk management system issues. However, environmental risk assessment not done in dairy farms (ABE-LABEE-DE, 2005). Since 2005, a new water strategy has been developed. The MMEH is currently known as the Ministry of Mines, Energy and Water (MMEE). A new Water Act will be amended soon and the Ministry is working on the updating of the regulations relating to water resources (Onibon *et al.*, 2006).

2.5.2.2. The institutions related to water pollution in Benin

- The national institutions related to environment and water pollution

Many different institutions play a direct or indirect role in the management and the use of water resources in Benin. Three types of public institutions were described by Onibon *et al*., (2006). These institutions are: public institutions with specific attributes related to the water sector, institutions with non-direct roles and state-controlled agencies that are international players with trans-boundary functions.

- o Public institutions with specific attributions related to the water sector
  Four ministries play a central role; these are listed below with their attributes:

1. The MMEH, currently known as the MMEE includes the General Directorate of Hydraulics and its technical departments; the Technical Secretariat for the promotion and the coordination of the GIRE (STPCGIRE); and the departmental directorates of the MMEE which are the decentralized institutions.

2. The Ministry of Agriculture, Livestock and Fisheries, which includes.

   - the Directorate of Rural Technology and Agricultural Engineering (Direction Genie Rural, DGR) in charge of constructing rural infrastructures (roads, dams, water points, and livestock markets etc);
   - the Directorate of Livestock;
   - the Directorate of Forestry and Natural Resources for the management of natural resources (this directorate is now under the authority of the Ministry of Environment);
   - the Regional Center for Agricultural Promotion (CeRPA formally CARDER); and
   - the CENAGREF: for the protection of natural resources.

3. The Ministry of Environment, Habitat and Urbanism (MEHU) now known as the Ministry of Environment and Nature (MEN) (MEHU website 2007) includes:

- o The Directorate of the environment, the Beninese Agency for Environment (ABE), as well as the Environmental Police for enforcing adherence to environmental policies and regulations. Since 2002 Environmental Cells were created into all the Ministries and work together with the MEN. They are involved in the environmental assessments relevant to their activities.

- The Directorate of Forests and Natural resources, previously located in the Ministry of Agriculture.

4. The Ministry of Public Health (MSP), now Ministry of Health (MS), with the directorate of Hygiene and the service of Sanitary Police.

The other Ministries (Ministry of Planning, the Ministry of Education, in charge of Scientific Research and Training) play a supporting role. All these institutions agree with the necessity for coordination within the sector of water.

- o Institutions with non-direct roles

There are also other role-players in the private sector that work with the state on water and environmental issues. These include Non-Governmental Organizations (NGO's), local communities and civil society. Various regulations related to decentralization give local community structures that are involved in environmental issues and water pollution, some level of responsibility for the management of water resources. Civil society and the Association of Consumers are, as yet, not completely involved in water issues.

Others that are involved in environmental issues and water pollution may not be committed only to the management of water. Their roles are briefly outlined below:

- The NGOs (national and international) play a role in social intermediation.
- Hydraulic substructures are built with the support of development partnerships. These include cooperation agreements with France, Denmark, The Netherlands, Germany, Belgium, the World Bank, PNUD/, UE/EU (European Union) and GWP/WAWP (GWP/WAWP, 2006)

- The Committees for the management of water places and water users play a role in the promotion of community systems for drinking water supplies used by urban human populations.
- The Committees for the management of pastoral hydraulic and water places in the villages (small dams, sinks and wells) are mainly concerned with the promotion of water supplies used by rural populations and livestock.

The success of the management of water resources in Benin as well as the surrounding countries induces regional and sub regional politics and strategies. These include:

- Other state controlled agencies that play a direct role:

The Basin Agencies, which are concerned in the management of trans-border water resources:

-The Basin Agency of Volta
-The Basin Agency of Niger
-The Basin Agency of Mono

2.5.2.3 Legislation on water pollution (Benin)

In Benin, very little legislation on water pollution exists. Despite the efforts of the state, application is slowed down by a lack of information, as well as a deficiency of environmental education and awareness. The majority of the data remains in the offices of the different institutions and cannot easily be found on websites, even though they exist in hard copy. Those that are quoted were searched out in the libraries and repositories of the relevant state departments in Benin and translated from the original French, as Benin is a Francophone country.

Legislation regarding the environment and water pollution is mainly related to executive bodies and organs of legislation. Executive bodies are represented by the Judicial, the Health Police and the Environmental Police, which are in charge of the inspection and control of the quality of water resources. Legislation and regulation offices in each department are responsible for the implementation of regulations that are already legislated.

The Republic of Benin does not, as yet, have a national policy for management of water resources. The draft of the new Water Act (Code de l'Eau) is in the process of being amended and legislated. Previous legislation, dating back to 1987, has never been implemented. A Document on National Politic Strategy in Water Resources Management and Basins has been written and will be amended soon (GWP/WAWP, 2006; Onibon *et al*, 2006).

Papers on sectoral strategy, (Sectoral strategic Plans) for water resources exist, but specific legislation related to water resources in the agriculture and livestock sectors, does not exist. Since the beginning of the "Environmental Action Plan" in 1993, many laws and acts have been passed by Parliament and have been given to the Ministry of the Environment and its institutions for implementation. This has resulted in a high level of improvement in the quality of water resources. Although water pollution by dairy is not included in specific laws and regulations, these can be used to implement the control of environmental pollution by dairy producers (MEHU website, 2007).

Tables 4.14 and 4.15 in Appendix 3 list laws and regulations relevant to water pollution in Benin.

2.6 A review of HACCP in regard to milk and dairy products

A definition of HACCP is given in the FAO/WHO[8] document titled "Codex Alimentarius Food Hygiene Basic Texts" (2001), as follows:

"Hazard Analysis and Critical Control Points (HACCP) is a systematic preventative approach to food safety that addresses physical, chemical and biological hazards as a means of prevention rather than finished product inspection. HACCP is used in the food industry to identify potential food safety hazards, so that key actions, known as Critical Control Points (CCP's) can be taken to reduce or eliminate the risk of the hazards being realized. The system is used at all stages of food production and preparation processes" (FAO/WHO, 2002)

HACCP is a quality assurance system based around seven principles and its implementation needs twelve steps based on a logical and progressive approach, as suggested by Codex Alimentarius Commission (Byrd & Cothern, 2000; Huss, 1996).

[8] http://www.fao.org/DOCREP/005/Y1579E/y1579e03.htm

Currently HACCP systems are used in SA and Benin for food quality control, but not to control, manage or mitigate the risk of water pollution by dairy production and processing. In this study, in line with the FAO's recent publication "Reconciling Livestock and Environment" (2007), it becomes important to note that food safety does not exist in a vacuum, but also involves the environmental consequences of food production. It is proposed that the same HACCP processes used for food safety can be used for environmental hazards resulting from dairy production and processing. Thus CCP's can be identified to prevent water contamination that in turn could prejudice food safety (FAO, 2007 (b)).

2.6.1 The history of HACCP and its developments

The HACCP concept has its origin in the USA and stands for "Hazard Analysis Critical Control Point". Its history can be shortly described as follows:

- In 1958 the NASA (National Aeronautics and Space Administration was founded.
- In 1959, the HACCP concept was developed to assure the complete safety of the food to be used in outer space.
- In 1971 the HACCP system was published and documented in the USA (Huss, 1996).

A number of regulatory authorities have progressively developed an interest in HACCP as a tool for use in food safety. In 1985, the National Academy of Science (NAS) recommended the use of the system which became used all over the world and the FAO/WHO Codex Alimentarius (Codex) has cited the system in the Codex (IAMFES, 1991; Hudak-Roos & Garett, 1992; Vose, 1996).

In 1993, the Codex Alimentarius Commission (CAC) gave HACCP international importance through the development and the adoption of guidelines for HACCP application. In 1997, after several Expert Consultations, CAC adopted basic texts on food hygiene, including a revised text on the HACCP system and guidelines for its application. The European Regulation 93/43 EG from14.7.93 provides for the use of HACCP for quality control in the production of food (EEC, 1993).

The HACCP concept was implemented and enhanced in Europe between 1988 and 1999 through various institutions. Guidelines as to its application were provided in an annex to the General Principles of Food Hygiene. Internationally, HACCP was successfully used in large food businesses supplying export markets because it became a basic requirement for quality and food safety control supported by the CAC (FAO/WHO, 2002, 2006 (a) and (b); Ghidini *et al.,* 2004).

As these changes occurred in the developed importing countries, producers of fish and sea food in Africa become aware of the potentially serious impacts on export markets and started to adapt to the new stricter safety-oriented quality assurance programs for food, based on the HACCP concept (Abul Goutondji, 2001; FAO/WHO, 2006(a); Huss, 1996; Tall, 2007).

Consequently, the HACCP system has been progressively introduced in Africa since 2000. In most of African countries, institutions of certification and normalization as well as those of Quality Assurance have organized training, regulation and the processes of HACCP implementation. The situation of HACCP system in Cameroon and SA is described in the" FAO/WHO Guidance to Governments on the application of HACCP in small and developed food businesses, 2006"(FAO/WHO, 2006 (a)).

The difficulties of applying HACCP in developing countries were recognized internationally. During the consideration of the draft HACCP standard (rev3) at the 22nd session of the CAC,[9] some delegations expressed their concerns about the difficulties of applying it to *"Less Developed Businesses*" (LDB's). Between 1997 and 2003, the HACCP Guidelines were reviewed in the Codex Committee of Food Hygiene (CCFC) *'to meet the needs of LDB's and developing countries"* (FAO/WHO, 2006(a)). After considering the matter of barriers to its application in developing countries, the last draft was adopted in 2003 at the 35th session of the Codex Alimentarius Commission. It was then agreed that FAO and WHO would develop HACCP guidelines for LDBs. The document has been finalized after peer review and was published in October 2006 (FAO/WHO, 2006(a)).

HACCP is currently used in place of the traditional systems of inspection, which presents some weaknesses (ICRI-FAO, 2004). It can also be used separately, or together with, the other food control systems, which are already standardized.

International food quality systems include those of the International Organisation for Standardisation (ISO), ISO 9001 for quality assurance, BS 8800 for health and safety and ISO 14001:1996 for environmental management. The norms for ISO 19011 are related to

[9] ALINORM 97/37, para 34

environmental audit standards, those for ISO 14000 focus on environmental management and ISO 22000: 2005, on a food safety management system. These norms should help to enhance the concept of globalisation and environmental security, during the implementation of HACCP systems in food production and processing. They can also be applied to dairy systems (ISO, 2005, 2007(a) and (b); ISO - TC 34/SC 5, 2007).

The three norms described above, have been harmonized to maximize the synergic effects of each system. Implementation of GMP (Good Manufacturing Practice) or GHP (Good Hygiene Practices) prior to HACCP implementation is a way to improve any food production or processing system. GMP/GHP is the foundation for HACCP implementation and requires considerable knowledge of food hazard analysis (Brand *et al.*, 2001; Casey & Meyer, 2001). According to the above points, the HACCP system concerns food products at all phases during production and processing and should be implemented without any restriction, from the animal on the farm to the fork of the consumer (Noordhuizen *et al*., 1997; Smulders *et al.*, 2004; Wall, 2004).

It is therefore logical that GAP (Good Agricultural Practices) at farm level, must be added to monitoring and prerequisites for animal products, if one is to follow the principle of food safety along the whole production and processing chain, sometimes called "Farm to Fork" or "Stable to Table" (FAO, 2002 (a), (b) 2003; Kirby *et al.*, 2003; Larsen & Hispen, 1997; Lievaart *et al.,* 2005; Michel & McCrindle, 2004 (a) & (b); Noordhuizen, 2004; Steinfeld *et al*., 2006). The FAO has developed a booklet, "Good Dairy Farming Practice" in conjunction with the International Dairy Federation (IDF), which is based on GAP. This publication also addresses environmental issues related to dairy farming (FAO/IDF, 2004)

Although the HACCP system application has been evolving rapidly in SA, it is not well implemented in the majority of other African countries. Lack of national regulations in such countries could be an important cause of this situation.

2.6.2 The HACCP concept; links with other control systems

The HACCP system is based on the principle that dangers exist in different aspects of a production process and that it is possible to take actions in order to minimize them (Bauman, 1992).

According to Kofer *et al*., (2004) and Lievaart *et al.*, (2005), the health of the consumer may be threatened by the following factors:

- Contamination and recontamination of food by pathogenic bacteria
- Parasites or chemical substances
- Survival of heat processing by pathogenic bacteria, later multiplication under favorable conditions and formation of undesired chemical reactions
- Formation of undesired toxic substances and bacterial toxins

The anticipation (risk assessment) of hazards and the identification of the control points are consequently major elements of the HACCP system. This system, aims to avoid the numerous weaknesses inherent to the approach by inspection, through a rational and logical approach for the mitigation of the risks during the process of food products.

2.6.2.1 The HACCP concept

According to the European rule defined in the document 94/356/EG, the HACCP concept should be integrated in a quality management system and has to be developed for all products of every production or processing facility (factory) (FAO, 2003).

Once the system is initiated, the quality assurance will mainly focus on the critical control points without having to indefinitely repeat analyses at the final level (CAC, 1999 (a) & (b)). These concepts could equally be employed for water safety in dairy production systems.

2.6.2.2 Elements of the HACCP system

The main elements in a HACCP system (CAC, 1997; CAC, 1999 (a)& (b); CAC, 2001; CAC, 2004; CAC, 2007(a); FAO, 2002 (b); Huss, 1996) are:

- Identify the potential dangers (hazards) and evaluate the risk (probability) of them occurring.
- Determine the CCPs in terms of places, process, and production steps.
- Determine the steps to be controlled in order to eliminate or reduce the dangers (hazards) to a minimum. At this level, a “decision tree” is essential.
- Establish the criteria to ensure that the CCPs are well respected; this implies a detailed description of the CCPs (direction, references values, shaping), thus the necessity of a suitable definition of production conditions.

- Establish a surveillance system. This requires that a maximum amount of data is gathered. This system must be simple and give rapid results and surveillance should be continuous or, at least, frequent.
- The monitoring system should preferably use statistical and sampling methods for data collection and the level of control should be monitored by visual observation, chemical or physical effects.
- Decisions should be made on anticipated counter-measures to be taken in case the selected CCPs are not successful in controlling targeted hazards
- The verification procedures should be anticipated and the documentation and archiving procedures established.

2.6.2.3 HACCP prerequisite programs, principles and steps

Even although the HACCP system measures are simple, implementation requires a logical and progressive approach, as suggested in 1992 by the working group on HACCP system of the Codex (CAC, 1999 (a) & (b); CAC, 2001; CAC, 2004; FAO, 2002; Huss, 1996; FAO/WHO, 2006(a)).

The WHO/FAO (2001) have emphasized that:

"*Prior to application of HACCP to any sector of the food chain, that sector should be operating according to the Codex General Principles of Food Hygiene, the appropriate Codex Codes of Practice, and appropriate food safety legislation. Management commitment is necessary for implementation of an effective HACCP system. During hazard identification, evaluation, and subsequent operations in designing and applying HACCP systems, consideration must be given to the impact of raw materials, ingredients, food manufacturing practices, role of manufacturing processes to control hazards, likely end-use of the product, categories of consumers of concern, and epidemiological evidence relative to food safety."*

Following on form the above, it is obvious that, prior to implementation, HACCP requires documented and monitored Pre Requisite Programs (PRP's) to be in place for the control of lesser hazards. These PRP's are managed usually through a Quality Management System (QMS) (Anderson *et al.,* 1990; Bauman, 1992; Hudak-Roos & Garett, 1992).

The PRP's are as follows:

- engagement of the organization;
- formation of the HACCP team and the necessary material;
- launching of the program;
- analysis of the fabrication process;
- the control procedures corresponding to each HACCP;
- the monitoring procedures; including the staff component involved in monitoring

The basic HACCP system, as it exists currently, has seven principles and its implementation requires twelve steps (FAO/WHO, 2002; Hudak-Roos & Garett, 1992; McCrindle, 2007)

The seven principles are:

- Principle 1 Conduct a hazard analysis.
- Principle 2 Identify the critical control points (CCP).
- Principle 3 Establish limits for each critical control point.
- Principle 4 Establish CCP monitoring requirements.
- Principle 5 Establish corrective actions.
- Principle 6 Establish record keeping procedures.
- Principle 7 Establish procedures for verifying the HACCP system is working as intended.

The HACCP system has twelve steps for the implementation of the system in an enterprise (Bauman, 1992; FAO, 2002, Huss, 1996; McCrindle, 2007). These steps are shown in Fig 3.6 in Chapter 3 Methods. In practice, these steps are implemented as follows:

- Step 1. The head of the enterprise names the Quality System (QS) Manager who is responsible for the installation of HACCP System.
- Step 2. The QS Manager names the members of the HACCP system's team.
- Step 3. The team determines what products can be handled together "Valid for".
- Step 4. The team makes a "Description of the Products".
- Step 5. The team makes a "Flow Diagram of the Products".
- Step 6. The team checks all documents.

- Step 7. The team marks all CPs on the flow diagrams.
- Step 8. The team identifies and marks all CCPs on the flow diagrams, trying to have a low number of CCP'S.
- Step 9. The team determines the tests to be made at the CCP's.
- Step 10. The team determines the corrections to be made.
- Step 11. The team determines the methods used to control the CCP's.
- Step 12. The QS Manager verifies if the system works or not and if the internal audits are made in time. The HACCP system should be rechecked periodically though the basic documents. It is a living and endless system (Huss, 1996; IAMFES, 1991).

In regard to the present concept and standards of Quality Assurance, the system of HACCP should consider the global protection of the consumer even though it can be used separately or together with other systems. It should take into account related aspects, such as animal health and welfare, the environment, hygiene and safety of the food (Kofer *et al*., 2004; Smulders *et al.*, 2004).

2.6.3 HACCP in SA

HACCP regulations[10] started to be implemented in 2002 by the Ministry of Health (DOH, 2006)

Since the 27th of June 2003, SA has been committed to the application of the HACCP system in food chains, through Government Notice No 908, in terms of section 15(1) of the Foodstuffs Cosmetics and Disinfectants Act, 1972 (Act No 54 of 1972), in the Schedule of the Regulations relating to the application of the Hazard Analysis and Critical Control Point System (HACCP). This system is implemented to identify, evaluate and control hazards that are significant to food safety (FEDICS, 2004; DOH, 2006).

According to the regulations, an owner of a food handling enterprise is responsible for ensuring that:

" *prior to HACCP implementation they operate in accordance with GMP - Good Manufacturing Practice and comply with all relevant health and safety legislation applicable to the foodstuffs and food handling operation; foodstuffs received from a producer or supplier for further handling by*

[10] www.doh.gov.za/docs/regulation/2002/reg494.pdf

the food handling enterprise in question comply with all the requirements for safety applicable to foodstuffs under consideration."

A food handling enterprise must then also enforce Supplier Quality Assurance (SQA) (FEDICS, 2004). This can be considered a prerequisite fro applying HACCP. With the regulation "Government Notice No 908 of 27 June 2003" which is under the Health Act 61 of 2003, HACCP implementation is imminent from farm to fork in SA's food industry. Although this regulation is not specific to the food industry, it is applicable to suppliers, storage, transportation, packaging, wholesale and retail sectors of the food industry. HACCP has to comply with the SA National Standard: SANS 10330 of 2006 (DOH, 2006; FEDICS, 2004; Jordan, 2007).

Although the critical importance of the HACCP system is widely understood in SA and the HACCP regulation has been legislated, few data related to its implementation are available. Less than 1% of South African companies have HACCP certification, the procedure of certification takes almost a year and HACCP is a continuous process, so certification will have to be repeated (FEDICS, 2004).

SA's dairy producers are aware of the necessity to be involved in the HACCP process because dairy products are manufactured for a commercial purpose. However the HACCP system is not yet well implemented at producer level and only a few dairy processors have implemented it since 2003/2004[11] (FEDICS, 2004; Personal observation). Milk audits however, include aspects of HACCP and its pre-requisites and are currently being implemented by milk distributors, on farm, so as to be in line with international norms (Jordan & Kraamwinkel, 2007; Visser, 2007).

2.6.4 HACCP in Benin

Quality assurance, as well as the HACCP system in the food domain, is essentially monitored by the Beninese Centre for Norms and Quality (CEBENOR), located in the Ministry of Industry, Trade and Employment promotion (MICPE), the National Direction of Alimentation (DANA) and the Directorate of the Promotion of Quality and Commercialization (DPQC) of the Ministry of Agriculture, Livestock and Fisheries (MAEP). These three public institutions work closely with the

[11] www.douglasdale. co.za

other departments, national committees, private institutions and other actors concerned by food quality and food safety[12].

The CEBENOR have been committed to the training of role-players and stakeholders concerned with food quality. Training courses and workshops are conducted with the partnership of national and international organizations including: The West African Economic and Monetary Organization (UEMOA/WAEMU), CEDEAO/ECOWAS, FAO, INFOPECHE, DANA, the Directorate of Fisheries and the Directorate of the Promotion of Quality and commercialization of the MAEP[9].

Benin is a signatory to several bilateral trade and business agreements. The country is involved in the process of bio-security and bio-safety through national strategy. Laws and regulations in Benin are based on international agreements and standards like ISO, GATT, and DOHA. However, the few national laws related to food safety are not always in line with rapidly evolving international regulations, because they are old and the drafts are not yet amended. The Health Code, the Water Code and the Public Hygiene Code all date back to 1987[14].

In Benin, quality assurance through HACCP has been used in a few factories involved in the production of manufactured foods such as canned or bottled soft drinks and shrimps, since the '90s.

The norm ISO 9000 is known and utilized in these factories and. the post of quality insurance inspector is fully integrated into the staff component. As Benin is involved in the export of shrimps, the concept of HACCP has also been introduced and implemented since 2000 in seafood factories, some poultry farms and poultry slaughter houses, but is still at the stage of primary planning in other food processing systems.[15] .

The consumers' association which exists in Benin is not fully aware of the HACCP concept and HACCP is unknown on farms and in the local markets. Very few factories are aware of the importance of this system, although they are informed of its existence as a part of quality

[12] **8** www.gov.bj.org, 2007
9 www.ISO.org, 2007; www.wto.org, 2007; www.mcipe.org, 2007; www.cebenor.org, 2007.

[14] www.wto.org, 2007
[15] www.mcipe.org, 2007

assurance; they are not as yet committed to implementation (Abul Goutondji, 2001; Personal observation, 2006).

Most of the dairy farms in Benin follow a traditional dairy production system. The majority of farmers have little formal education and few, other than those on the state farms, are aware of the concept of quality assurance for dairy products (Dudez & Broutin, 2003). Legislation related to this concept in dairy production in Benin, does not exist. However, some role-players involved in dairy processing have been educated during training courses organized by CEBENOR/UEMOA since 2003. Thus, a few dairy processing factories have started to implement the HACCP system as well as environmental policy, in their quality and environmental management systems (Personal observation, 2006).

2.7 The role of the veterinarian regarding dairy farming and water pollution

Many authors have described and reflected on the role of veterinarians and the changes in the profession. Most of them have agreed that despite the multi-dimensional aspect of the profession and the multiplicity of skills and performance of the professional, changes in the profession are required to meet the concept of globalization (Akakpo *et al.,* 2006; Pappaioanou, 2004; Sidibe, 2003; Smulders & John, 2004). Veterinarians are supposed to play a specific role in the milk chain, using the concepts, steps and principles of HACCP. In this way, they will enhance the tools and competencies required for effective monitoring and control of food and environmental safety linked to animal production (Collins, 2004; Giessecke *et al.,* 1994; Guard & Brand, 1996; Smulders & John*,* 2004).

2.7.1 Legislation, jurisprudence, ethics

In Benin, regional and governmental institutions using veterinary personnel are involved in sanitary policy, sanitary protection, hygiene and sanitation, public health, and animal health (ONMVB, 2004). However, quality assurance through HACCP as well as environmental issues, have not yet been implemented in the monitoring of dairy products. Although specific legislation related to dairying and water pollution does not exist, the country is engaged in the process of quality and environmental policies through international norms such as ISO 9000, ISO 14001, ISO 19001, Codex, FAO guidelines and EU Directives (CAC, 1999(a); CAC, 2007(a) & (b); CEBENOR, 2007; UNEP/DEWA~EUROPE*,* 2007).

Nevertheless, veterinary professionals are aware of the necessity for change and some training strategies for continuing professional development (CPD) have been explored. Veterinarians are involved in quality and environmental audit teams, as well as environmental assessment teams, related to food of animal origin (see Table 2.14 in Appendix 3). Environmental cells exist in each Ministry, for multi-disciplinary involvement in environmental assessment in Benin. These include veterinarians when needed (MEHU website, 2007).

SA has been involved in the commercialization of dairy products for several generations of farmers and processors. Quality assurance has been a part of dairy processing for decades and recently, legislation on HACCP in dairy products, has been implemented (Collins, 2004; DOH, 2005; Jordan, 2007; Jordan & Kraamwinkel, 2007; Lactodata, 2007; NDA, 2006; Noordhuizen *et al*., 1997). Food safety and environmental legislation are strongly focused and closely tied to the international norms[16]. Currently the majority of the stakeholders and role-players involved in the food chain are aware of the importance of quality insurance and the HACCP system (MPO, 2007; SAMIC, 2007). SA legislation on food safety rapidly follows the global changes related to VPH (FEDICS, 2004). However, the implementation of dairy effluent and waste-water management is comparatively recent and veterinarians do not appear to be systematically involved in the monitoring of this management.

2.7.2 Protection of water resources

The role of the veterinarian in the protection of water sources is not well defined, except for their role in monitoring the safety of drinking water used by livestock. However, environmental health forms part of the curriculum of veterinary students in both Benin and SA (Michel & McCrindle, 2004; ONMVB, 2004; University of Pretoria, 2007)[17] and it is hoped that the role of the veterinarian in all aspects of pollution resulting from livestock production and its control will increase with time.

2.8. Literature review of international regulations, criteria, norms and standards

International criteria, norms, standards and legislation are monitored by several organizations, which frequently work in synergy. The quality and environmental management of dairy products and water are closely linked (WHO, 2000 (b)).

[16] http://www.gov.za
[17] http:/www.up.ac.za

The most important organizations involved in food and water safety and quality are represented by Codex, FAO, ISO, WHO and OIE. The World Trade Organization (WTO) and some European and American organizations have part of their activities oriented towards dairy and environmental issues and play a support role.

2.8.1 Codex Alimentarius Commission

Codex represents the world authoritative reference on food standards. It is an intergovernmental organization mandated to develop food standards for the protection of consumers' health and the insurance of fair practices in the food trade **(**WHO, 2001).

Codex is:

> "…*an extensive 13 - volume compilation of Food Standards, Codes of Practice, Guidelines and Recommendations, based on the principle of sound scientific analysis and evidence which are voluntary utilized by national food inspection systems, health authorities, the World Trade Organization, the food industry, scientists and consumer advocates* "(CAC, 2007; FAO/WHO, 2006 (b)).

Codex was formed in 1962 by the WHO and the FAO of the United Nations to:

> "…*develop food standards, guidelines and related texts, such as codes of practice under the Joint FAO/WHO Food Standards programme. The main purposes of this programme are to protect the health of consumers and ensure fair trade practices in the food trade, as well as to promote the coordination of all food* standards work undertaken by *international, governmental and non-governmental organizations"* (CAC, 2007(a); FAO/WHO, 2006(b)).

Codex was established and mandated to:

- Safeguard the health of all consumers by setting standards for food safety and food quality.
- Enhance fair international food trade practices.
- Co - ordinate work on international food standards.

- Manage the compilation and updating of food standards.

Two types of standards compose the Codex: the *General Standards* and the specific *Commodity Standards.* The general standards are handled by corresponding general subject committees; the following commodity issues are developed into these standards:

- food labeling,
- food additives,
- contaminant,
- methods of food sampling and analysis,
- food hygiene,
- nutrition and foods for special dietary uses,
- food import and export inspection and certification systems,
- residues of veterinary drugs in foods,
- pesticide residues in foods

Issues around milk and milk products are detailed in Commodity Standards (CAC, 1999(b); CAC, 2004). The corresponding commodity committees develop or elaborate standards, guidelines and related texts (CAC, 2007(b)).

Codex standards, guidelines and recommendations (WHO, 2001) are the reference features considered by the WTO (WTO, 2006) to settle international trade disputes on matters related to food safety. The *Agreement on Sanitary and Phytosanitary Measures (SPS Agreement)* is the international standard for food safety. Although not specifically referenced, the *Agreement on Technical Barriers to Trade (TBT Agreement)* also uses Codex standards as international references[18].

The list of codex standards can be found on the Codex website[19].

In this list, standards related to dairy are focused on the nutritional quality of milk, labeling and the safety of milk and milk products. Most of the safety standards are related to potential hazards due

[18] http://www.wto.org
[19] http://www.codexalimentarius.net/standard_list.asp ; http://www.FAO and WHO 2006

to microbiological organisms, milk contaminants and residues. It is these that are most likely to be affected by polluted water.

Some standards regarding drinking water for human use, bottled water, urban water or mineral water can be found in Codex but standards related to natural water resources issues are not. Water standards are only developed in terms of food production and processing.
The baseline criteria that have been developed into Codex standards are thus:

- Food hygiene.
- Food safety.
- Food quality.

In July 2000; the CAC adopted a strategic framework which emphasized food safety issues in developing countries. It was emphasized that efforts should be made to enable developing countries to build their own food quality and safety systems (FAO/WHO, 2002 (c); FAO/CAF, 2005; FAO & World Bank, 2006).

FAO has also initiated a Global Facility on Food Safety and Quality for the Less Developed Countries, to strengthen their national food regulatory systems and their competitiveness in the international food trade (FAO, 2002(c); FAO CAF 05/2, 2005; FAO & World Bank, 2006).

2.8.2 International Organisation for Standardization

Although it occupies a special position between the public and private sectors, the ISO is a widely known as an international NGO that develops standards. ISO is a network of the national standards institutes of 157 countries, on the basis of one member per country, with a Central Secretariat in Geneva, Switzerland, that coordinates the system. It is one of the few NGO's that has an observer status in the WTO; it also collaborates regularly with the major international organizations involved in metrology, quality and conformity assessment (ISO, 2007(a)).

ISO works closely with the UN and its specialized agencies and commissions, particularly those involved in the harmonization of regulations and public policies. These organizations include Codex (for food safety measurement, management and traceability) and the WHO (for health technologies).

Its technical committees have formal liaison relations with some 580 international and regional organizations. The ISO standards provide governments with a technical base for health, safety and environmental legislation, which makes trade between countries easier and fairer, as well as safeguards consumers and users in general. ISO also plays a role in the transfer of technology to developing countries.

The principal activity of ISO is the development of technical standards that have economic and social repercussions. Those standards help engineers and manufacturers to solve basic problems in production and distribution. The three most important series of ISO standards related to food are ISO 9000, ISO 14000 and ISO 22000 (ISO, 2007(b)).

- The ISO 9000 series is currently considered as the international reference for quality requirements in business and ISO 14000 aims to achieve in helping organizations to meet their environmental challenges. ISO 9000 and ISO 14000 are known as "*Generic management system standards"* and can be applied to any organization. The product, processes or activities, the establishment or not of a quality management system or an environmental management system, is not of great importance for the implementation of these standards - they are universally applicable (ISO, 2007(a); ISO 2007, (b), 2005 (a) and (b); ISO - TC 34/SC 5, 2007). It is important to note that the baseline criteria for food quality developed by ISO 9000 were food hygiene and food safety.

- The ISO 14000 series are related to environmental issues and specifically aligned to environmental management. (ISO, 2007(b)). The baseline criteria developed by ISO 14000 series were the minimization of the negative effects on the environment caused by an organization through its activities it includes continuous environmental performance evaluation (ISO, 2007(b)).

- The ISO 22 000: 2005. Food safety management systems are essential for any organization involved in the food chain. It is a new standard which is designed to ensure a safe food supply chain, for good practice on a worldwide basis. It aims to provide a harmonized framework of requirements that will respond to a global approach. This framework tends to offer an easy and harmonized method for the implementation of the Codex HACCP system for food. The ISO certification is not compulsory for the implementation of the HACCP system; however food safety management systems that conform to ISO 22000 can be certified. The global vision of the organization for 2010 is developed in the ISO Strategic Plan 2005-2010 (ISO, 2005). It should be noted that the baseline criteria developed by ISO 22000 series concerns both food safety and environmental performance.

The ISO standards related to milk and milk products are mainly concerned with the quality of milk. However, some of them are related to environmental goals and a few (ISO 22000, 2005-norms) take into account the specific aspects of the impact of dairy on the environment (ISO, 2005).

2.8.3 OIE Standards

The OIE is the World Organization for Animal Health. Annually, the Organization publishes the *"Terrestrial Animal Health Code"*, formally the "*Zoosanitary International Code*", which contains specific regulations on animal diseases and includes Veterinary Public Health issues and zoonoses. OIE collaborates with the WHO, the WTO and the FAO (OIE, 2007(b)).

OIE regulations related to human diseases originating from animals (zoonoses) are made in collaboration with WHO[20] (Droppers, 2006). These include zoonoses and food borne diseases that are found in dairy animals and their products.

OIE standards may be used by WHO and FAO. It should be noted that the baseline criteria for OIE standards and regulations concern animal diseases and animal health issues.

2.8.4 World Health Organization regulations

WHO works closely with OIE and FAO to establish regulations related to human health and welfare. Milk plays an important role in food security, particularly in developing countries. Thus some regulations related to milk safety for human consumption have been established by the WHO[21], although some animal diseases related to milk have not yet been included. It should be noted that the link to this study are those WHO regulations that are related to human diseases resulting from animals or animal products (zoonoses). These criteria concern mainly the quality of milk and milk products involving animal diseases listed by the OIE. The WHO criteria for the safety of milk are closely tied to those of the OIE and FAO.

[20] www.oie.int
[21] www.who.int., 2007

2. 8. 5 Food and Agriculture Organization

The FAO uses Codex or ISO standards to establish criteria related to food-borne diseases, zoonosis or nutritional safety of food[22].

Recently there has also been a major focus on the role of livestock in the environment (FAO, 2007, Steinfeld *et al.,* 2006).

2. 9 A review of risk assessment for water pollution

Risk assessment is part of risk analysis for water pollution and varies according to the scope of the assessment. Some definitions need to be given prior to the literature review, to explain some of the terminology used in this field. Risk assessment procedures also include a choice and a conceptualization of a model which is different according to the appropriate parameters.

2. 9. 1 Definitions

According to US FDA/CFSAN (2002):

- "***Risk*** *is the likelihood of the occurrence and the magnitude of the consequences of exposure to a hazard on human health*". The hazard can be biological, chemical or physical.
- *"**Risk analysis** is a valuable tool to enhance the scientific basis of regulatory decisions"* (US FDA, 2002). The risk analysis framework includes three components: risk assessment, Risk mitigation/management and risk communication.
- ***Risk assessment*** has several different definitions that will be discussed in more detail below.

2. 9. 2 The meaning of risk assessment

The concept of risk assessment has been developed in the last three to four decades because people have realized that human activities can have adverse effects on their environment. These effects come from chemical, biological or physical hazards. Since 1970, international legislation,

[22] www.fao.org., 2007

namely the *Clean Water Act,* the *Clean Air Act,* the *Comprehensive Environmental Response and* the *Compensation Liability Act,* have required risk assessments[22] (FAO/WHO, 2002).

Risk assessment is an iterative process where project goals are conducted by multidisciplinary teams, according to certain principles, within the risk analysis framework. Risks should be identified and selected using a decision-tree based approach (Aphis, 2005(a); Aphis, 2005(b); OIE, 2007 (a))

Resources needed for risk assessment must be identified and realistic timeframes established prior to the conduct of the process. The successful conduct of risk assessment is entirely based on an open exchange of information and ideas within and among the team involved in the risk analysis framework. Risk assessments should be simple and the process must be transparent and undergo regular peer reviews by government and non-government experts; it should be comprehensive and accessible to the public (US FDA, 2002; FAO/WHO, 2002; Kofer *et al.*, 2004). Government regulatory agencies, state environmental agencies, companies or organizations, whose work may impact the environment and non-governmental organizations, are all involved in environmental protection issues (Anelich, 2002).

Although they are basically the same, various definitions of risk assessment are given depending on the organization, the goal and the scope:

- *"Risk assessment is the characterization of the potential adverse health effects resulting from human and ecological exposure to environmental hazards. The risk assessment process is complex and includes the steps below:*

  1. *Hazard identification is the analysis of an environmental situation to find out if there is a probability for an exposure of an organism or ecosystem to an environmental stressor to cause harm.*
  2. *Dose-response assessment is the process of the characterization of the relation between the dose of an agent received by a receptor (organism or ecosystem) and the incidence of an adverse effect of that receptor.*

3. *Exposure assessment is the process of measuring or estimating the intensity, the frequency or the duration of a human or ecological exposure, to current or future agents in the environment.*
4. *Risk characterization is the process of estimating the incidence of an adverse effect under the conditions of exposure described in the exposure assessment. It is also the narrative description of the meaning of the assessment, and the uncertainties in the preceding steps"* (Roberts, 1999; U.S/FDA, 2002; Vose, 1996; Wall, 2004).

- *"Risk assessment is the scientific evaluation of known or potential effects resulting from human exposure to hazards. The process consists of the following steps: hazard identification, exposure assessment, hazard characterization (dose-response), and risk characterization"* (US FDA/CFSAN, 2002).

- *According to Codex, risk assessment is "…a scientifically based process with four steps: hazard identification, hazard characterization, exposure assessment, and risk characterization." (CAC, 1999a)).*

- The definition of risk assessment by OIE is: *"The risk assessment process consists of four interrelated steps. These steps clarify the stages of the risk assessment, describing them in terms of the events necessary for the identified potential risk(s) to occur, and facilitate understanding and evaluation of the outputs. The product is the risk assessment report which is used in risk communication and risk management. The steps of risk assessment according to OIE are: Release assessment, exposure assessment, consequence assessment and risk estimation"* (OIE, 2007(b)).

- In regard to the science-based approach, Nguz in 2002 defined risk assessment as "*a process through which information on risks is identified, organized and analyzed in a systematic way to get a clear, consistent presentation of data available for practical decision-making. Without going through the risk assessment process, there is no scientific basis for regulatory decision-making"* (Nguz, 2002).

Whichever of the definitions are accepted, risk assessment remains a prediction based on probability and uncertainty. Risk characterization is the final step of the risk assessment which integrates hazard identification, hazard characterization and exposure assessment; the results are an estimation of adverse effects likely to occur, including relevant uncertainties and are fundamental for decision making. Although the steps of hazard characterization and exposure assessment in some risk assessments should mathematically determine the degree of uncertainty of the likelihood of risk occurrence, qualitative risk assessments are equally acceptable (FDA/CFSAN, 2002). Risk assessments are handled according to different strategies. The goal, the scope and the strategy determine the choice of the model of the risk assessment. Models of risk assessment are numerous and vary with the organization (Larsen & Ipsen, 1997; Mathot, 2004; Steinfeld et *al.,* 2006).

Risk characterization can be quantitative, qualitative or a mixture of both, as long as it is scientifically based. The results and meanings of the assessment depend on various parameters including field data or modeling of uncertainty. The description of uncertainty is very important in all the steps of the process (Kirby *et al.*, 2003; U.S. FDA, 2002).

2. 9. 3 Models of risk assessment

Models of risk assessment depend on various criteria. Numerous different models of water pollution can be conceptualized and risk assessment for these different models depends on the method or strategy, the choice of the parameters, and the existing data on water pollution (de Jong, 1996; Dornom, 2004; Draaijer, 2000; Edinburgh Centre for Toxicology, 2007). The last of these is most difficult as there is not often sufficient data available on all the variables involved. Thus:

- The number of parameters (variables) determines the complexity of the assessment. The fewer the parameters, the more simple the assessment will be.
- The availability of minimum data-base determines the feasibility of an assessment as well predicting the likelihood of improvement in a specific situation
- Corrective actions would have to be proposed and taken, to allow an improvement in the situation.

Risk assessment in environmental investigations is often conducted by way of ongoing modification, based on continued improvement and the models chosen should thus be flexible. A simulation of the conceptualized model can be made and used for refinements of further risk assessments (CAC, 2004; OIE, 2007 (a)).

2. 9. 4 Valuating in risk assessment

The limits between the different components of risk estimation are not always clearly defined. According to some authors, risk estimation is the first step of the risk management framework which has three components. These components are the dose-response assessment, the exposure assessment and the risk characterization (OIE, 2007(a)). These components are mentioned by others as part of the risk assessment process (CAC, 2007(a); US FDA, 2002).

"Valuating" means that the hazards identified are given a value (qualitative and quantitative if possible).

Different methods are used to give a value to an assessment: quotation, percentage or classification into a specified category (Roberts, 1999). Either quantitative or qualitative risk assessments are valid if they are based on scientific data. In some cases descriptive assessments are of interest and are more or less qualitative. If these are used, then numerical values are not given in the risk assessment. Some authors consider the quantitative estimation of risk as a step towards risk management, especially when a mathematical model is chosen. However, it has been suggested that mathematical models are as fallible as qualitative models because risk, itself, is a form of uncertainty that cannot be definitely quantified. However, when doing qualitative risk assessment, it is important that data gaps and assumptions are acknowledged and sensitivity analysis can help deal with sources and analysis of uncertainties. (DEFRA, UK, 2006).

The quantitative estimation of a risk may require several aspects to be quantified and its refinement varies according to the stage, the complexity and the priority of the risk assessment, because it is an iterative process. The uncertainties and the severity of the problem should be considered for decision-making or quantitative risk estimation with avoidance of an unnecessary effort. In fact quantitative risk assessments for complex, high priority risks can be time - consuming and expensive (OIE, 2007(a)). The magnitude of the risk should also be considered.

The limits between the different components of risk estimation are not always clearly defined. According to some authors, risk estimation is the first step of the risk management framework which has three components. These components are the dose-response assessment, the exposure assessment and the risk characterization (OIE, 2007(a)). These components are mentioned by others as part of the risk assessment process (CAC, 2007(a); US FDA, 2002).

According to (DEFRA, UK, 2006) evaluation of the magnitude of the risk is based on:

- Estimation of the probability of event.
- Actuarial or historical information.
- Synthesized analysis using fault tree analysis and event tree analysis.
- Estimation of the magnitude of the consequences.
- Estimation of the probability of the consequences.

2. 9. 5 Risk assessment for water pollution

"*Water Resources Assessment is the determination of the sources, extent, dependability and quality of water resources, on which is based an evaluation of the possibility for their utilization and control*" (Larsen & Ipsen, 1997).

Risk assessment for water pollution should integrate data related with water resources assessment (as described above), because it is part of water resources control. Interventions to reduce risk exist at international, national and local level because the increase of water pollution concerns the entire population worldwide. (Larsen & Ipsen, 1997)

At the international level, Agenda 21 was agreed in Rio de Janeiro, Brazil in 2000. This is an action plan to guide national and international activities, with a specific chapter on the management of toxic chemicals (WHO, 2007). The Convention on Persistent Organic Pollutants (POPs) has been adopted as an international legally binding instrument. National legislation on water pollution is currently seen as important, because the health link between clean water, nutrition and livelihoods needs to be better understood by communities.

During the World Water Day[24] organized by the WHO in 2001, it was accepted that water pollution comes mainly from industry, mining and agriculture. The basic principles and actions of risk assessment related specifically to water pollution were defined. It has been specified that combined actions such as Health impact assessments (HIA's) should be done together with the traditional EIAs to improve risk assessments and enlighten health public aspects. Although models of risk assessment are not static and should be flexible, some basic frameworks developed by WHO, OIE and FAO, can be used to conceptualize combined models for risk

[24] http://www.who.int/water_sanitation_health/industrypollution/en/index3.html

assessment of water pollution. The risk assessment of water pollution should also include food assessment aspects, health assessments as well as environmental aspects and can be used for field simulation. The basic frameworks which can be used are as follows:

- The Environmental Impact Assessment (EIA) which is an assessment of the likely influence of a project on an environment and the mitigation of the biophysical, social and other effects. Water pollution impacts were established through pathway analysis which became the basis of the global ISO 14000 series of environmental management standards and the more recent ISO 19011 auditing standard. EIA[25] predicts what a specific action can do to the environment. EIA is a process, prior to major decisions and commitments related new projects. (After an EIA analysis, the characteristics of the likely environmental harms of a project can justify the application of the Precautionary Principle and Polluter Pays or require strict liability or insurance coverage to a project. (ISO 9000/14 000, 2007).

- The Health Impact Assessment (HIA) proposed by OIE and WHO, is an assessment of the environmental effects (here water pollution) on human and or animal health. It should be seen as a risk assessment related to diseases due to the consumption of polluted water (OIE, 2007(a); WHO, 2007).

- HACCP developed by Codex, is a specific framework of risk assessment for food which can also be used for water; HACCP is explained above in section 2.4 of the present chapter.

- The Environmental/Ecological Risk Assessment (ERA) developed by US/EPA; the framework for the ERA is shown in Figures 3. 4 and 3. 5. of Chapter 3.

Both dairy products and water might be dangerous for the consumer if they are not well managed and if they do not meet all the safety criteria required for both humans and animals. The production of milk and dairy products from farm to fork has many effects on water resources which reflect the interactions between cattle, water-resources and humans. Globalization of dairy control suggests that the HACCP system could be used to improve quality assurance of milk and dairy products in a country (Lievaart *et al.,* 2005).

[25] http://en.wikipedia.org/wiki/Environmental_Impact_Assessment, 2007.

2.10 A review of the meaning of risk management and mitigation

Risk management and mitigation is the second component of a risk analysis process (US FDA, 2002). Risk estimation is the combination of the probability of the consequences and the magnitude of the consequences and it is the basis for risk management. As said above, risk estimation can be qualitative and or quantitative. The estimation of a risk assessment involves the establishment of the broader significance of this risk and the implications of the risk problem including social, political and economic considerations. Many factors influence the significance of the risk: statutory and policy requirements, value judgments, social aspects, changing environment and changing baselines. These judgments about the acceptability of risk are the basis for decision - making on how to reduce or manage the risk (DEFRA UK, 2006).

For many social analysts, academics and politicians, risk management is the management of environmental and nuclear hazards, organizations and humans. Those risks are specifically macro-risks which are technology- generated and represent a threat to our existence when they appear. Risk mitigation and management are related. The risk management process can be summarized in seven steps:

- Establishment of the context.
- Identification of the risk:
  - Assessment of the risk.
  - Determination of the potential risk treatments.
  - Creation of a risk mitigation plan.
  - Implementation of the risk mitigation plan.
- Review and evaluation of the plan.

The objective of any risk management is to define how to prevent, control or reduce a specified risk. It attempts to reduce a risk over the long term using planned strategies. The main objective is to reduce a risk to a level accepted by the society. Risks can be mitigated by risk avoidance, risk reduction; risk retention or risk transfer (FAO/WHO 2001).

For this study, the mitigation of risks of water pollution in the dairy sector will be examined at the level of implementing existing legislation, or proposing new legislation, that can be used to prevent or control water pollution by dairy effluents or dairy herds.

2. 11 Overview of current policies in SA, Benin and at the international level (policies on the current development of the dairy chain and the protection of water resources

At the international and national levels, several policies relevant to the dairy chain and the protection of water resources are developed.

2.11. 1 At the international level

Dairy policies that are under international bodies result from countries and institutions working together, although some points of view are different and subject to controversies. International organizations such as the International Dairy Federation (IDF), FAO, WHO, OIE, IDF/IFCN and the WTO have, over time, developed different policies and regulations, mainly oriented towards production, consumption and marketing, However, between 2001 and 2002, the fall of the milk price led to a number of trade-related policy measures being developed for importing and exporting countries (FAO, 2002(b)). Since the failures of the "*DOHA Trade Talks"*, several amendments have been made. These amendments chiefly concern the domestic aspects of dairy production, food safety, the environment and human health. Food safety and quality aspects are related to the organic aspects of milk and to implication in trade issues (WTO, 2006; WHO, 2007). Environmental aspects are becoming a topic for regulation, because of the negative impacts and the existence of hazards from dairy industries for water resources (DEFRA UK, 2002 & 2006).

At the international level, two tendencies are noticeable, with regard to the economic aspects of the dairy industry: the USA policies on one side and the EU policies on the other (WTO, 2006). These policies focus specifically on the maximization of economic income from dairy in the relevant countries.

2. 11. 2 Policies at the national level in both countries

In SA there is a long tradition of commercial dairy farming with exotic dairy breeds; the dairy industry is well structured and there is a strong relationship between all the stakeholders on one hand side, and with the government, represented by the DOA on the other. Animal health and dairy management issues have evolved in a positive way to enhance the quality and safety of dairy products. The above mentioned Department works together with the DoH to improve health issues. Dairy strategies and policies are strongly based on regularly amended legislation. Production, consumption and marketing policies are implemented and maintained by a well organized dairy sector. Milk programmes and policies have been developed over the last few years (NDA, 2003 and 2005). SA is currently developing trade policies and strategies for exportation in balance with the requirements of EU and the United States. Thus, the current goal is the improvement of milk quality standards on the farm, including improvements in milk hygiene and quality as well as animal welfare issues and care of the environment .The improvement in regulation of the dairy sector is now being adjusted to the current trends of an increasingly competitive market. SA is also committed to the implementation of quality management systems, such as ISO 9000 and HACCP for food quality, in line with the highest international norms. In addition, the DSA is linked to local commodity and producer organizations as well as and the IDF. Several processors, such as Parmelat SA and Clover have international connections and are interested in marketing to the African continent and beyond (Hanak *et al*, 2002; Mwangi & Omore, 2005; USDA /US Embassy, 2003).

With the adoption of the Water Act in 1998 and its relevant regulations, management of water resources in SA has been evolving over the past decade. The DEAT and the DWAF have also worked together to implement the by-laws and relevant sections of the Environmental legislation (AQUASTAT, 2005a; Country Studies US, 2006).

There are traditional, small scale and large commercial dairy farms in SA. However the number of milk producers has decreased by 47% from 3899 since 1997 while milk consumption is increasing. There are a few larger processors at national level and a large number of smaller processors in specific areas. During 2006, 31 000 tons of dairy products were imported and 25 000 tons were exported (LACTODATA, 2007).

Strategies and legislation related to, dairy products and water resources are well developed in SA. These are generally well managed in SA in the commercial dairy sector, although not well implemented at farm level, in the informal (traditional) sector (Martinus, 2001). It should also be noted that the quality control of milk in SA relies heavily on market forces rather than state control. Supermarkets and processors will not buy milk or dairy products unless they meet international criteria for safety and quality. These international criteria are aligned to OIE and FAO policies and directives that are beginning to include environmental impacts of agricultural activities. Informal markets, however, are very similar to those of other African countries (Manzana, 2007; Prozesky *et al.,* 2004)

In Benin, livestock and dairy farming are traditional activities that have existed for centuries. With the increase of the demand for milk and dairy products, sectoral strategies have been implemented. One of the Government priorities is the development of milk production through the improvement of milk collection and distribution. Genetic improvement through the introduction of tropical breeds, Gir and Girolando, is also included in the interventions adopted. Trade policies are in line with international regulations for importing countries and Benin follows these policies which are monitored by the *Union Economique et Monétaire Ouest Africaine* (UEMOA) and the ECOWAS/CEDEAO. However the role and the competency of the national institutions and stake-holders still needs to be clearly established (DE, 2003, 2004 and 2005; MAEP, 2004; FAO/ TCP, 2005).

Water pollution is a major constraint to maintaining a sustainable supply of potable water in Benin. The improvement of water quality is also included in national strategies. The National Water Act is also the main goal for water governance and the integrated improvement of water resources (Onibon, *et al*., 2006).

Strategies related to control of water pollution concern the quality control of water resources, which are the endpoints in the chain of pollution. The sources of pollution and specifically agricultural sources are not yet well characterized. Specific data about the effects of the dairy industry on water are scarce. Overlapping functions and lack of clarity about the responsibility of different institutions make is the matter more complex. The deficiency of specific legislation related to the protection and control of water resources from dairy residues and effluents prevents a targeted approach. The government of Benin is working currently to elaborate a logical framework for the national institutions involved in livestock on one hand and water resources and management on the other (Benin Government website[26], 2007; AQUASTAT, 2005 (c) & (d)).

In summary Benin is a very low producer of milk and dairy products; livestock and dairy farming are chiefly traditional. However, since 2000, state farming is being developed and sustainable

[26] www.gouv.bj

improvement of milk production is expected. Although legislation relating to milk, dairy products and water resources are very scarce, the relevant national strategies have started to be developed. However, the prevention of water pollution by milk and dairy products is not prioritised. This offers an opportunity to suggest changes in legislation based on those of an African country where legislation for the control of dairy farming and water quality monitoring is already well established, such as SA.

CHAPTER 3

MATERIALS AND METHODS

3.1 Introduction

The present study chiefly targets the negative effects of dairy on water resources and the way to minimize them through regulatory measures. Water pollution control should be managed through an integrated approach (Braden *et al.*, 1990; Casey *et al.*, 1998; Casey & Meyer, 2001; Kofer *et al.,* 2004).

The objective of this approach is to deal with the weakness and the difficulties inherent to crisis management when dairy production leads to water pollution. The goal of this study is to investigate the potential problems of water pollution by dairy, in respect to current legislation in Benin and SA. The study will suggest possible improvements to regulatory measures that could be undertaken to decrease the risk of water pollution by the dairy sector (Anderson *et al.*, 1990; Dornom, 2004; Emond, 2006; FAO, 2002(b); Larsen & Ipsen, 1997).

Risk analysis is an inherent part of this study. Whatever the definition or the method used, risk analysis traditionally has three components: risk assessment, risk management and mitigation and risk communication (APHIS. 2005(b); Bauman, 1992; Byrd & Cothern, 2000).

After a global overview of the research problem, the present study will focus chiefly on qualitative risk assessment of water pollution by dairy production. The HACCP sequence will be chiefly used as the research model or framework for the study (Horchner *et al*., 2006). Critical control points for each dairy farming system will be identified, in each country and the current legislation in both countries examined for points that would reduce the hazards for water safety that were identified. The study will also use, if needed, some principles of environmental risk assessment (ERA). The results will lead to suggestions for regulatory decision-making that will improve risk mitigation, risk management and risk communication (Edinburgh Centre for Toxicology UNEP/IPCS, 2007; Hudak-Roos & Garett, 1992; Huss, 1996; IAMFES, 1991; ISO, 2005)

3. 2 Risk analysis aspects of the research

Risk analysis, as mentioned previously, includes hazard identification, risk assessment, risk mitigation /management and risk communication (U.S. FDA, 2002; Vose, 1996). It is suggested that using international methods of risk analysis, including hazard identification, risk assessment and risk management/risk mitigation, an in-depth study of the legislation in SA and Benin will result in development of a risk-communication strategy in each country, to improve animal and human health and promote cleaner water and better levels of milk hygiene.

3. 2. 1 Hazard identification and characterization

In line with international norms, the hazards to human health, animal health and the environment (in particular water safety) resulting from dairy production in Benin and SA will be identified and characterized into the following categories: (OIE, 2007(a) and (b); Schillhorn van Veen, 2005; Schlundt *et al*., 2004; Steinfeld *et al*., 2006; WHO, 2001; WTO, 2005):

- physical hazards;
- chemical hazards; and
- biological hazards.

The potential hazards will be identified by field trips to selected dairy outlets in each country, literature review on dairy farming systems and by observation and informal interviews with stakeholders (both farmers and veterinarians in the dairy industry). Baseline criteria for hazards to water safety from dairy production will be connected with international standards (CAC, 2007 (a) & (b); FAO / IDF, 2004; ISO, 2005; ISO, 2007 (a); ISO, 2007 (b); OIE, 2007 (b)).

Flow diagrams for the dairy farming systems in each country will then be designed, using field results and data obtained from literature review (Borland, 2004; Horchner e*t al*., 2006; Mathot, 2004; Lievaart *et al*., 2005; Robinson, 2002; Schmidt & van Vleck, 1988).

3. 2. 2 Risk Assessment

Risk assessment is defined as identification and estimation of the likelihood and magnitude of potential risks; anticipation of the risks and evaluation of the probability for future risks (APHIS, 2005 (a), (b)). The type, likelihood and magnitude of the risks that would result from the hazards that were identified for dairy production, will be estimated. Once this has been done, potential or effective CCP's in the dairy chain supply will be identified and recorded. Using decision trees, flow diagrams will be redrawn and show the possible CCP's (Horchner *et al.,* 2006; Radostis, 2001).

Although risk assessment is an important step within the framework of risk analysis, it should be flexible, to allow continuous improvement and corrective actions; uncertainties will be mentioned as far as possible. Mitigation and communication of the risks cannot be done without having achieved this step.

3. 2. 3 Risk management and mitigation

Using flow diagrams, the current legislation in SA and Benin will be studied, to see if there are sufficient legal controls in place to force the use of suggested criteria for quality control of water pollution due to dairy production. By products (such as effluents from any level of the dairy - production chain) will be included in this investigation (Borland, 2004; Braden & Lovejoy, 1990; Brand *et al.*, 1996; Brand *et al.,* 2001; Emond, 2006; Kirby *et al.,* 2003; Steinfeld *et al.*, 2006). If the criteria exist in the legislation, then CCPs can be put in place where the production process can be monitored. If the legislation does not recognize the specific criteria identified, then suggestions will be made for future policy changes. This will result in management of the risks to people and animals through water pollution by the dairy industry.

3. 2. 4 Risk communication

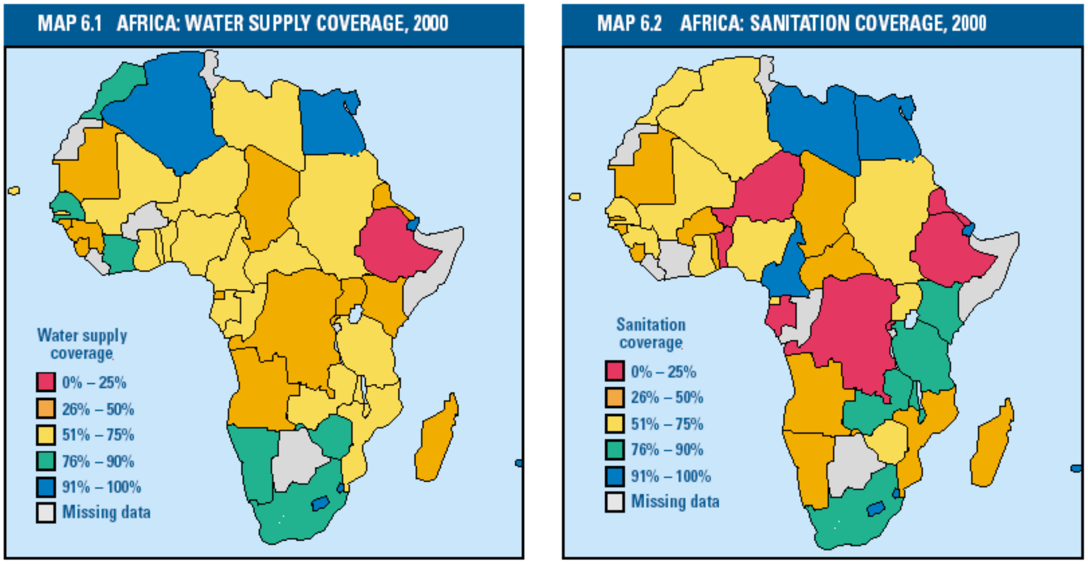
Once the research has been completed and risk management strategies developed, a risk communication strategy will be developed to inform stakeholders and policymakers.

3. 3 Model system and justification of the model

The model system is a prospective, proactive study examining the existing farming systems and legislation at this time and suggesting policies for the future. The HACCP model used for water pollution by dairy is based on that described for feedlots by Horchner *et al*.(2006).

3. 3. 1 Study area (Selection of areas)

The study areas are the countries of Benin and SA. The water supply and sanitation coverage of the two countries are shown in Figure 3.1.



<u>Figure 3.1</u>: Maps of Africa showing the water supply and sanitation coverage (WHO, 2000(a))

Benin is a country in French-speaking West Africa, which has a coastal line on the Atlantic Ocean. There are 12 Departments, centrally governed, with veterinary services represented in each department. The capital is Porto Novo, but the chief directorate of livestock, which manages all veterinary services, is located in the economic capital, Cotonou, in the department of Atlantic. To the East, lies Nigeria, to the north lie Niger and Burkina Faso and on the west lies Togo. The climate is sub-equatorial and the main river is the Oueme, which flows southwards. Farming occurs mainly in the two northern regions but also in the central region (AQUASTAT, 2005 (c) and (d)).

The study focus will be on legislation promulgated by the Government of Benin, which is directly applicable to the environmental impact of dairy farming and dairy by-products. See Figure 3.2.

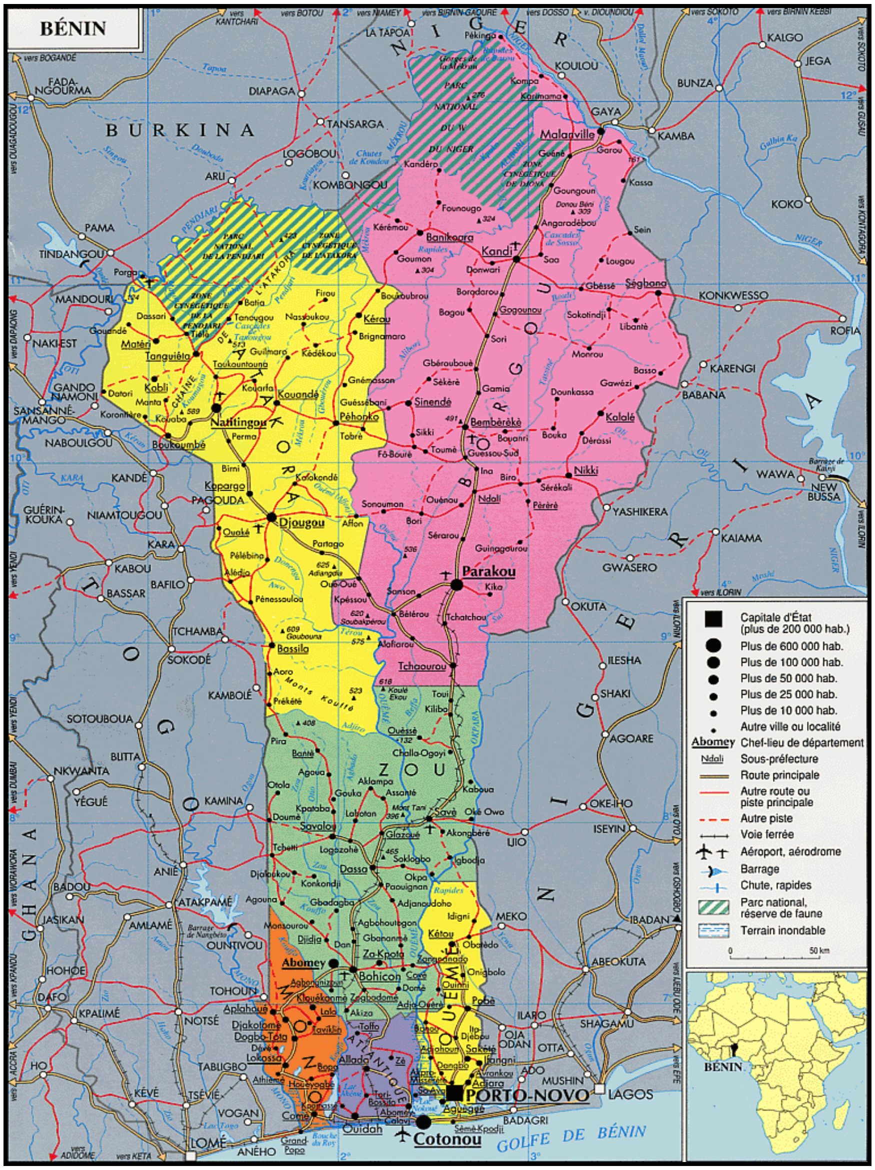


Figure 3. 2: Map of Benin. Source: URL *http://g.bb.free.fr/gbb/benin 2.htm* accessed online November, 2007

SA is located at the tip of Africa and is surrounded by oceans. To the north it is bordered by Namibia, Botswana, Zimbabwe and Mozambique. It has nine provinces; each has a regional directorate of veterinary services, which fall under the Provincial Department of Agriculture. The provincial directorates are independent but veterinary services also have a directorate under the National Department of Agriculture.

Figure 3.3: Map of SA. Source SA case study available at URL http:// www.unesco.org/wwap/case_studies/index.shtml

There is both provincial and national legislation governing environmental, health and veterinary matters. Rainfall is of prime importance with three main regions: a winter rainfall area in the southwest, an all year round rainfall along the southern coast and a summer rainfall area inland. Droughts are common and the average rainfall varies from less than 125 mm a year to more than 1000 mm per annum along the East Coast. The East Coast is considered to be the best area for dairy farming and many large - scale commercial dairies are situated there. However, commercial dairy farming, also takes place near most of the large urban areas in SA. Traditional and small-scale farmers are scattered throughout the country (AQUASTAT, 2005 (a) and (b)).

A comparison between populations and sanitation coverage in Benin and SA is given in Table 3.1.

Table 3. 1: Population and % sanitation coverage, Benin and SA, 2000 (FAOSTAT, 2005 (a), (b), (c), (d); INSAE, 2004 and 2005).

Country	Total Population1 (Thousands)	Urban Population (Thousands)	Rural Population (Thousands)	% Urban Sanitation Coverage	% Rural Sanitation Coverage	% Total Sanitation Coverage
Benin	4 660	1 607	3 053	46	6	23
SA	40 377	20 330	20 047	99	73	86

It is important to note that the figures for Benin are significantly lower than those for SA. This is important, as Benin is moving in the direction of commercial dairy farms, where a high level of sanitation is required for public health.

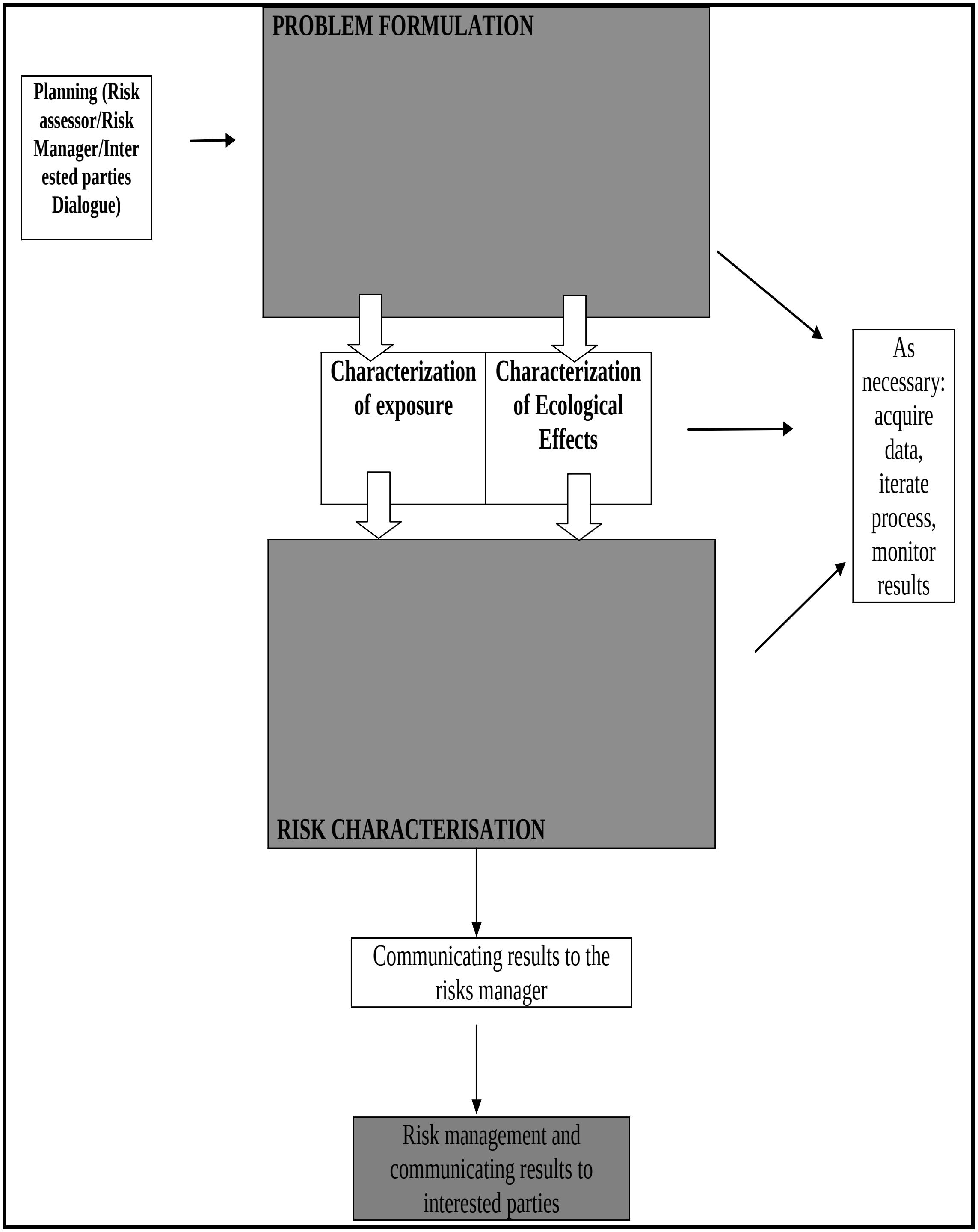
3.3. 2 The framework for risk assessment

The "framework for ecological risk assessment" was developed by U.S. EPA, (1998). In this model, the two major parts are the characterization of the exposure and the characterization of the effects.

As HACCP is a tool for a decision-making for food quality issues, so are environmental impacts (EIA) and risk assessments (ERA) for environmental issues. Improvement of regulations cannot be made without considering the concepts embodied in these tools. Most of the principles of HACCP and some of water pollution risk assessment will be combined in this study to conceptualize the model. The risk assessment will be a qualitative evaluation of the magnitude and likelihood of the identified hazards of dairy origin negatively affecting water (Larsen & Ipsen, 1997; Libby & Bogges, 1990; Lievaart *et al.*, 2005; Lunning *et al.*, 2002; Mathot, 2004; Nguz, 2002; Noordhuizen *et al.*, 1997; OIE, 2007(b); Tall, 2007; U.S. FDA, 2002; Young, 1990).

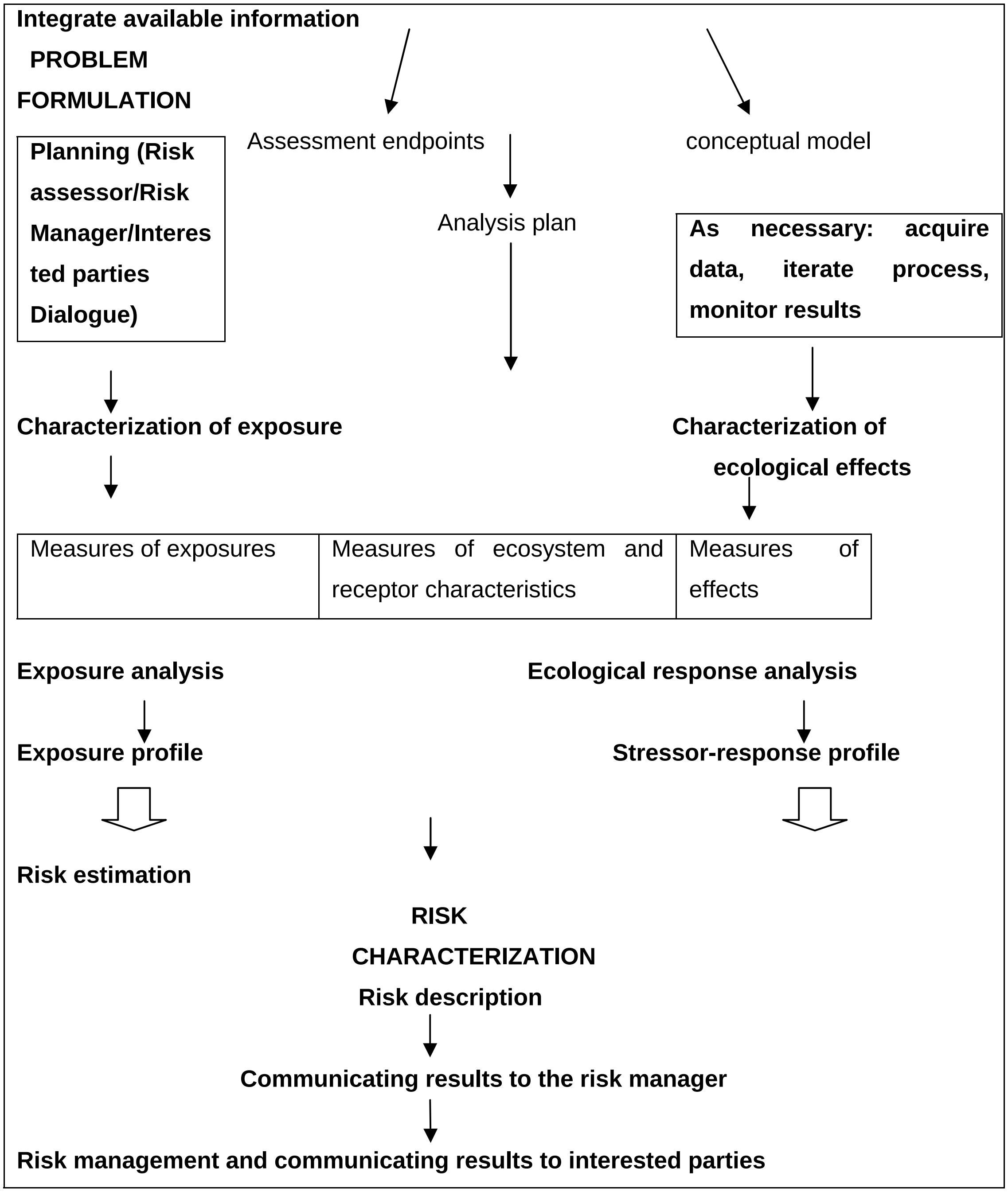
Ecological Risk Assessment:

Figure 3.4 and 3.5 below show diagrams that illustrate the framework used for ERA and an expanded framework, respectively.



<u>Figure 3. 4</u>: The framework for ecological risk assessment (Vose, 1996)

This model is a basic, comprehensive model, which could be repeated and extrapolated to other dairy products or other animal -originated foods.



<u>Figure 3. 5</u>: The framework for ecological risk assessment with an expanded view of each phase (Vose, 1996)

3.4. Methods

Different levels of water pollution control, according to the existing situation have been described. Although control is not completely legislated in either country, we can say that they have already passed through the "*Crisis management level of strategy*" (Larsen & Ipsen, 1997). In other words, a stable situation in regard to water pollution by dairy-by products currently exists in both countries, which are not actually at the level of "Crisis management" (Mbogoh, 1984). However, in line with the environmental hazards outlined in the FAO book "Livestock's Long Shadow", the risks of future pollution cannot be underestimated and actions must be put in place now (Hempen *et al.,* 2004; HSUS, 2005; Michel & McCrindle, 2004 (a) and (b); Noordhuizen *et al.*, 1997; Noordhuizen, 2004; Schlundt et *al*, 2004; Segerson, 1990; Steinfeld *et al.,* 2006; WHO, 2000).

Every step of the risk assessment will be handled using the respective strategies. The assessment will be based on the mix of dairy and water policy instruments and tools in each country. Data collected on existing dairy and water quality criteria, standards, legislation and management will be compared to the international criteria (Anderson *et al.*, 1990; Braden & Lovejoy, 1990; CAC, 2001; CAC, 2004; CAC, 2007(b); Collins, 2004; Copeland, 2002; DOH, 2007; DWAF, 1999; FAO/IDF, 2004; FAO/WHO, 2006; ISO, 2007(a); NDA, 2006; OIE, 2007; WTO, 2006).

In this design, the main factors to be considered are the following:

- Planning and field visits: observational data on potential hazards.
- Data collection on policy and legislation from the literature and personal interviews.
- Risk assessment, HACCP and environmental impact assessment based on observations, stakeholder informal interviews, expert opinions.
- Data analysis and comparison.
- Evaluation of the legislation to see if it gives sufficient control to implement the suggested risk management/ mitigation strategies.
- Interpretation of the results of the analysis and development of risk mitigation/management strategies.
- Discussion and comparison of possible changes to regulation to improve risk management in preventing water contamination/ pollution by dairy in Benin and SA.
- Recommendations.

3.4.1 Description of the procedures

Using HACCP procedures and the model of ecological risk assessment, the steps below will be followed:

- Data will be collected in both Benin and SA. These data are chiefly related to dairy systems, the regulations and the process of water resources management and water pollution control in both countries. They will be used for the risk assessment.

- A farming systems approach and field's visits are required to check on the implementation of the regulations (Brand *et al*., 1996; Brumby & Gryseels, 1984; Fandeso, 2004; FAO & World Bank, 2006; Faye & Loiseau, 2002; Maree & Casey, 1993; Matthewman & Chabeuf, 1993).

  Data analysis will be conducted through comparative tables and flow diagrams relating to the processes of milk harvesting and fabrication of dairy products within farming systems (Borland, 2004; Casey *et al.,*1998; Casey & Meyer, 2001; de Jong, 1996; Dornom, 2004; Dossou *et al.*, 2006; Draaijer, 2000; Gertenbach, 2007; Giessecke *et al.*, 1994; Guard & Brand, 1996; Norman, 1995; Norman *et al.*, 1995).

- Photographs will be taken, illustrating the farming systems in each country (Appendix 1, 2).

- Results will be based on the information found in the literature review identified farming systems and the evaluation of the legislation. A theoretical model of risk assessment adapted to the results of the comparison will be conceptualized. Suggestions will be made to mitigate the effects of the risk (CAC, 2001; CAC, 2004; CAC, 2007; FAO/WHO, 2006(b); GWP/WAWP; Horchner *et al.*, 2006; ISO TC 34/SC 5, 2007; Noordhuizen, 2004; Onibon, *et al.,* 2006; Owen *et al.*, 2004; Young, 1990; Zwart & de Jong, 1996).

3.4.2 Data collection

A literature review has been conducted through university and state libraries in both countries and using websites and the documentation centers of international institutions such as the FAO (See Chapter 2). A study of published legislation in both countries requires that copies will be made or acquired. Data on the situation of dairy systems and water resource issues in both countries will be compiled. A complete list of the specific laws and regulations on the above topic will be compared.

During visits in SA and Benin, observations will be made and photographic evidence will be obtained to draw flow diagrams and design HACCP in dairy farms. The photographs are shown in Appendix 1 and 2.

If possible, estimated or documented values for the main chemical, physical and biological hazards in each country will be obtained in collaboration with state veterinary officials and academics in both countries. Regulations and basic criteria for water safety and disposal of dairy-related effluents, in each country were listed and compared (CAC,2007(a); DE, 2003; 2004, 2005; DOH, 2005; FAO, 2005; IDF, 2005; ISOTC 34/Sc5, 2007; MAEP, 2004; MAEP/DE/PDE III, 2004; NDA, 2003/2005; OIE, 2007(b); WHO, 2007).

3.4.3 Farming systems approach

This step was necessary to obtain an overview for comparison between the literature review and reality. The approach was observational and qualitative (rather than quantitative). (Brand *et. al.,* 2001; Brumby & Gryseels, 1984; FAO/World Bank, 2006; FAO, 2002; Guard & Brand, 1996; Kofer *et. al.,* 2004; de Jong, 1996; Manzana, 2007; Mwangi & Omore., 2002; Mbogoh, 1984; Michel & McCrindle, 2004; Zwart & de Jong, 1996).

Informal interviews were done with purposively selected dairy producers in Benin, based on the, requirements listed in the *FAO Guide for Good Dairy Practices,* (FAO/IDF, 2004).

Baseline criteria applied to the data included:

- Animal health was evaluated against WHO and OIE standards (OIE, 2007; WHO, 2007).
- Good Farming Practices (GFP) and Good Management Manufacturing Practices (GMP) in dairy were rated according to FAO standards and criteria (FAO/IDF, 2004).
- ISO 9000 series and Codex Alimentarius Guidelines were the basic criteria for the evaluation of milking procedures and residues (ISO, 2007; CAC, 2007(a)).

- Environmental management hazards were rated against the ISO 14000 series and ISO 22000 series to see if the mitigation in the legislation was in line with the norms (ISO, 2007(b); ISO, 2005).

3.4.3.1 In SA

Field visits to commercial large and small-scale producers in Gauteng, North West, Eastern Cape and Western Cape Provinces were done and photographs taken to illustrate the farming systems, produce flow diagrams and identify potential hazards. The knowledge and implementation of the environmental and milk hygiene legislation by the informal dairy sector has been well described by Prozesky *et al.,* (2004) and Manzana, (2007). Dairy farming systems in SA were also characterized from available literature (Maree & Casey, 1993; Meyer *et al.,* 1991 & 1997; Burger 2005 & 2006; SA online, 2006).

Because most of the information was readily available from the field visits and literature, structured interviews and checklists were not used in SA.

Observations and photographs, visits to the farms and the breeders in both countries, was one leg of triangulation of the data required for risk analysis. The other two legs were literature review of farming systems and legislation.

3.4.3.2 In Benin

Compared to SA there is very little international literature available on farming systems and implementation of milk hygiene and environmental legislation at farm level, in Benin. Legislation is not available on the internet and state offices must be visited in order to get copies of the relevant Acts, Policies and Laws, which are all in French as Benin is a Francophone Country. Dairy farms are also widely scattered and individual visits required, as the farmers are not on internet or even contactable by phone or post (Akuesson, 2001; Broutin *et al*., 2001; DE, 2004; Kees, 1996; MAEP/ DE/ PDE III, 2003, 2004 & 2005).

The following data on Benin will be gathered by observation, structured and informal interviews and checklists:

- Farming systems: personal visits to six traditional agro-pastoral farms, one of the three state farms involved in milk production, and one private farm.

- Personal informal interviews with state officials in the Department of Agriculture as well as the Department of the Environment, to obtain relevant legislation on milk hygiene and the environment.

The data obtained will be used for hazard identification and characterization, as well as estimation of the type and magnitude of risks for animal and human health and the environment (water). HACCP has been well described in Chapter 2 and the details on the concept and the procedures are given in Section 2.5.2.1.

3.4.4 Data analysis

Data was analyzed and tabulated according to the main activities of dairy farmers in Benin and SA. Flow diagrams were drawn and characteristics of dairy farming systems in each country were described in detail. Potential hazards were identified and characterized for each dairy farming system. Decision tree analysis was done for each activity in each dairy farming system, to extract the CCPs.

Data on control of water resources and dairy production was extracted from the reviewed legislation from Benin and SA. This data was compiled and compared with mitigation required for each identified hazard, in line with international norms. The potential effects of water pollution on humans, animals, and water resources were evaluated through qualitative risk assessment (CAC, 2007(a); FAO, 2007(a); OIE, 2007(a)).

In summation, the key to this investigation will be hazard identification and characterization, coupled with an evaluation as to whether existing legislation in each country is sufficient to mitigate the identified hazards to water by dairy production (Dornom, 2004; Draaijer, 2000; Horchner et *al.,* 2006; Kofer *et al.,* 2004; Larsen & Ipsen*.,* 1997; Noordhuizen, 2004 ; Steinfeld *et al.,* 2006).

3.4.5 Conceptualization of risk assessment: theoretical model of risk analysis and risk assessment

3.4.5.1 Definitions

As mentioned previously, risk analysis has three components: risk assessment, risk management and risk communication.

To further explain risk assessment, it must be noted that whatever the definitions are, all of them emphasize the fact that the results of risk assessments or exposure assessments are a condition for risk management and risk communication.

According to Codex, *Risk assessment is*

"A scientifically based process with four steps: hazard identification, hazard characterization, exposure assessment, and risk characterization" (CAC, 2001; CAC, 2007(a)).

The definition of Risk assessment by OIE is the following
"The risk assessment process consists of four interrelated steps. These steps clarify the stages of the risk assessment, describing them in terms of the events necessary for the identified potential risk(s) to occur, and facilitate understanding and evaluation of the outputs. The product is the risk assessment report which is used in risk communication and risk management. The steps of risk assessment according to OIE are: Release assessment, exposure assessment, consequence assessment and risk estimation."(OIE, 2007(a))

Some variations are noticeable whether the scope of the risk analysis is food, animal or human safety or environmental security. Both definitions show the importance of hazard analysis. In the Codex definition, hazard identification is included into risk assessment, while in the OIE definition; it is an essential step which must be conducted before the risk assessment (CAC, 1997; CAC, 2007; OIE, 2007(a)).

The principles of risk assessment are globally the same whatever the definition. All of them make a strong point about the flexibility of the procedures. Risk is essentially a prediction or probability. Due to the multiplicity of the risk factors and the uncertainty of the measurements, qualitative or quantitative methods are both valid (U.S. FDA, 2002).

The concepts of the risk analysis approaches are globally similar, despite the different definitions by Codex Alimentarius, OIE or environmental organizations. In essence, risk assessment approach can be defined according to various considerations of food policy: international, regulatory, consumers, business, science-based or political.

According to WMO/UNESCO (1991) "*Water Resources Assessment is the determination of the sources, extent, dependability and quality of water resources, on which is based an evaluation of the possibility for their utilization and control*" (Larsen & Ipsen, 1997).

In regard to the science-based approach, Nguz in 2002 defined Risk assessment as "*a process through which information on risks is identified, organized and analyzed in a systematic way to get a clear, consistent presentation of data available for practical decision-making. Without going through the risk assessment process, there is no scientific basis for regulatory decision-making"* (Nguz, 2002).

3. 4. 5. 2 The place of HACCP in the model of risk assessment of water pollution by dairy production

Generic frameworks for managing food borne risks have been recently proposed by the Codex Alimentarius Commission (CAC, 2004; CAC, 2007(a)) and are based on application of HACCP (CAC, 1999(a) & (b)). This study is based on the HACCP approach (Horchner *et al*., 2006; Noordhuizen *et al.,* 1997).

According to the Codex Alimentarius Commission, hazards or risks that are relevant to risk management decisions should be identified according to risk profiling (CAC, 2002; OIE, 2000 and 2007(a)). An overview of the respective production systems in both countries and a list of the activities associated in these dairy systems will be used to built flow diagrams and to make a risk profile of the whole farming system in both countries (Horchner *et al*., 2006).

This study is based on developing and mitigating the hazards to environmental water supplies caused by dairy production, in line with international norms of good practice (OIE, 2007(b), FAO/IDF, 2004; ISO, 2005). The principles and criteria of good dairy farming practice developed by the FAO in 2004 (FAO/IDF, 2004), are used for the comparison and for specific risk assessment related to water pollution. Those criteria are as follows: animal health, milking hygiene, feeding, water, animal welfare, and environment. Thus some steps of environmental risk assessment have been included in the present HACCP sequence. When applicable, potential milk safety hazards and potential water related hazards are identified. (Horchner *et al.,* 2006; Steinfeld *et al.*, 2006)

Following the "Logical sequence for the application of HACCP" recommended by the Codex Alimentarius Commission, another decision tree is used to determine the control points (CPs) and identify the Critical control points (CCPs). The 12 steps of HACCP, described in Chapter 2, are summarized in Fig 3.6 below.

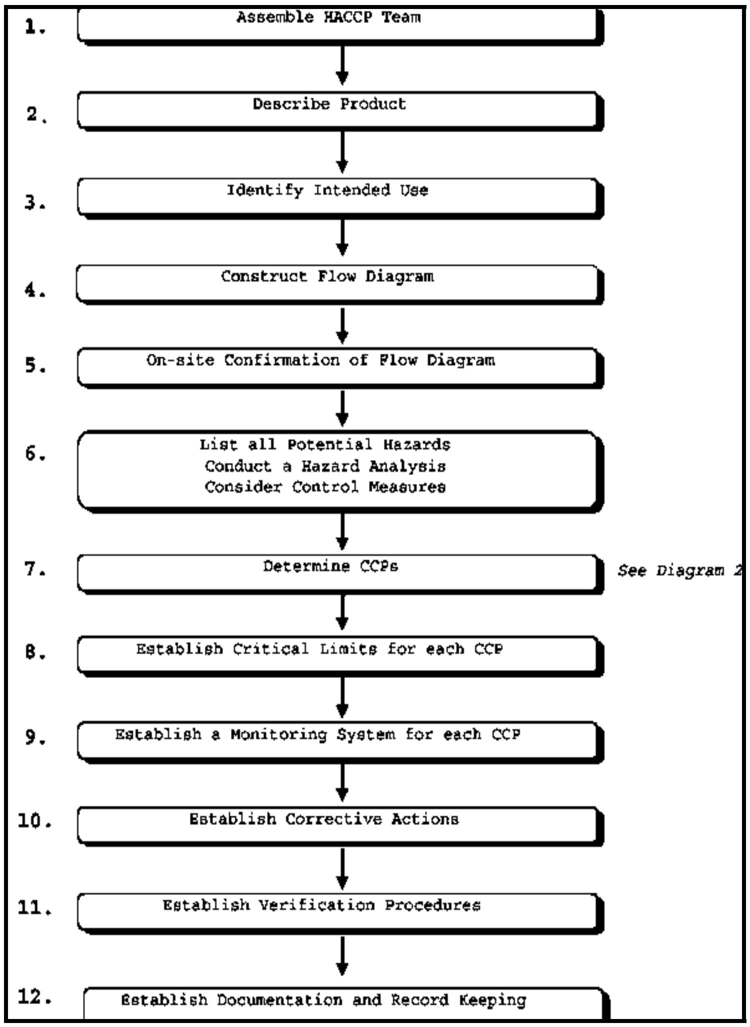


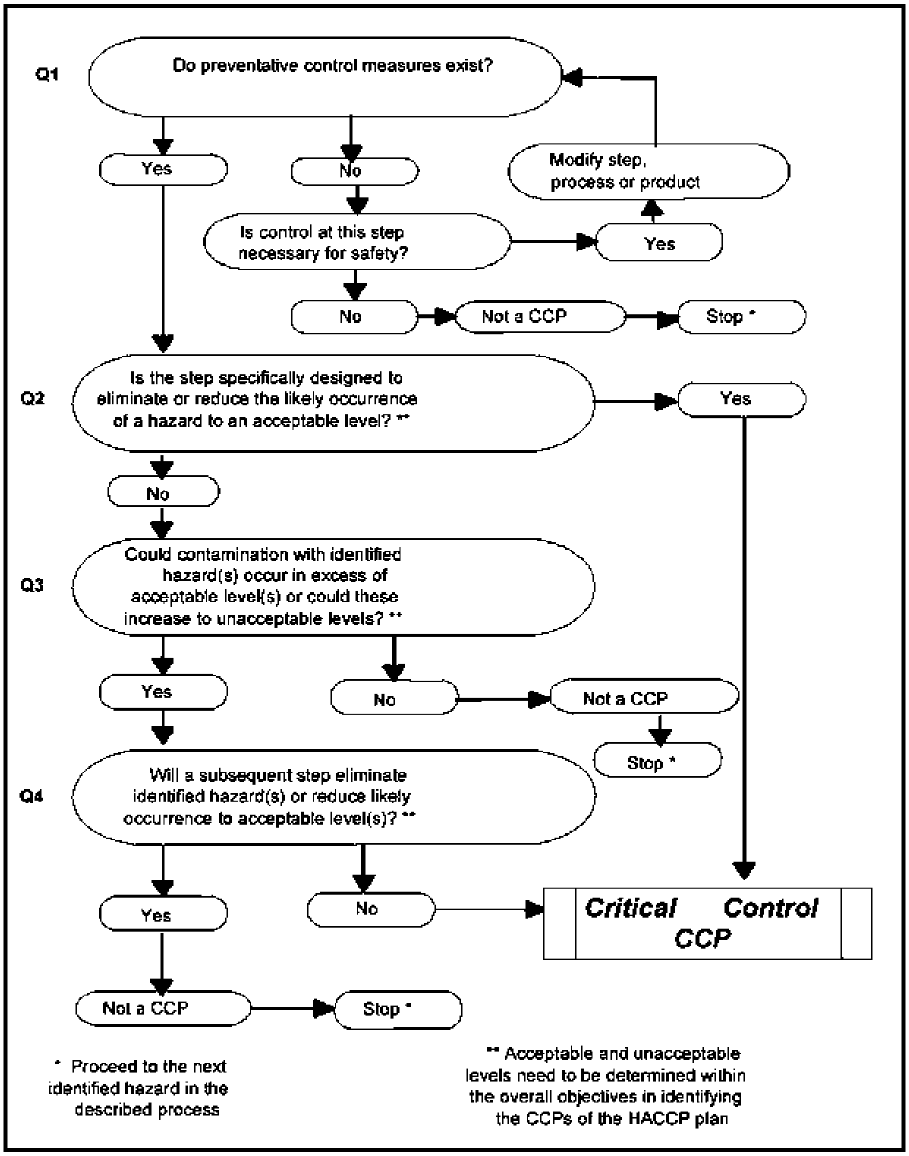
Figure 3.6: The 12 steps in HACCP according to FAO/WHO (2001). Diagram 2 above in the illustration, refers to decision tree analysis (see Fig 3.7)

The classical sequence of HACCP approach is modified to deal with the data obtained and some steps are subject for a further development to substantiate the current results. Steps 1, 2, 4, 5, 7, 9 of the traditional HACCP-concept (Bauman, 1992; Hudak-Roos & Garett, 1992; IAMFES, 1991; Vose, 1996) will be adapted with that of an environmental assessment. Thus, a combined method based on the HACCP - concept and the EIA concept will be used in the study (Libby & Bogges, 1990; Lievaart *et al*., 2004; Sergeson, 1990).

The results of each HACCP step, as applied to the current study, are summarized below:

- Step 1 related to HACCP team will be realized when an on-field risk assessment is conducted. For the present study, the HACCP team will comprise a veterinarian experienced in the application of HACCP methodology (the researcher) and role-players/ stakeholders involved in dairy and /or water resources management in Benin and SA.
- Step 2 and 3: The product, in this study, is actually the effluent or by-products from a dairy production system which could reach water resources in the environment. These products should be made environmentally safe through processes on the dairy farm.
- Step 4 and 5: An overview of process flow chart and activities for each types of farming system will be shown in Figures 1 to 7 and Table 4.1 of chapter 4. These process flow charts are the basis for a risk profile.
- Step 6 / Principle 1- Conduct a Hazard analysis; Identification of hazards and potential hazards (Figure 4.8 (decision tree) and Tables 4. 10 to 4. 12) of Chapter 4. Flow diagrams will be built to show the situation of water use, water depletion and the potential hazards during the process of milk harvesting. The characterization of the hazards will be qualitatively analyzed and take into account the uncertainties. The risk/ exposure assessment, also called hazard characterization, describes the nature, magnitude and likelihood of the risks to water associated with the identified hazards. It will be estimated from field data and the above flow diagrams for dairy farming systems.
- Step 7 / Principle 2: A derivation from a decision tree is pertinent to the determination of the CCPs (See Figure 3.7). Decision trees based on international regulations will be used to design risk mitigation strategies for identified risks and to evaluate whether these strategies are covered by existing legislation or policies in both countries, as described for feedlots by Horchner *et al*., (2006). The treatment of CCPs and CPs for the control of potential hazards will be shown in Chapter 4. CCPs will be determined through flow diagrams. From the identified hazards; points where such risks can be identified and controlled will be highlighted. However, qualitative HACCP values (based on three ratings: Not important, Fairly important and Very important) of standards, criteria and tolerances, will be derived from the flow diagrams, based on the literature, observed dairy farming practices and FAO norms for water safety in dairy. The situation of the existing

regulations will be compared with the CCPs. This will be considered as a **consequences assessment**.



<u>Figure 3.7</u>: Using a Decision Tree to determine CCPs. Source: FAO/WHO (2001)

The remaining HACCP principles applicable to CCPs, chiefly concern the management/ mitigation of the identified risk and list suggestions that could be made.

The application of step 1 is necessary before the study deals with further steps. Steps 8, 9, 10, 11 and 12 will then be developed for the implementation of risk communication and management. These steps are the following:

- Step 8 / Principle 3- Chosen values of critical limits for each CCP should be specified and validated after further analysis and various controls, in comparison with the norms or absolute criteria. This step will follow the conclusions drawn from the study (Chapter 6), after examination of all current applicable legislation.
- Step 9 / Principle 4: This step is related to the monitoring of the CCP's. It is a scheduled step within the risk management. The stakeholders and the regulatory prerequisites for ongoing monitoring of water quality and compliance by all dairy producers will be suggested from the conclusions of this study (Chapter 6).
- Step 10 / Principle 5: This is related to corrective actions in connection with regulatory violations, deficiencies or deviation when observed, which should be developed for each CCP. Counter measures in accordance with the strategies and the level of existing or proposed regulatory measures in each country will be proposed in Chapter 6.
- Step 11 / Principle 6: To verify if the present model of risk assessment is working, lists of procedures of verification are established for each CCP. A list and timing of random sampling and analysis as well as auditing/ review of procedures should be proposed. Verification is beyond the scope of this study, which will merely propose CCP's.
- Step 12 / Principle 7: A list of necessary documents for accurate and efficient record keeping on is proposed (Food safety and international dairy and water safety regulation and norms; Guide of GDP of FAO, 2004), process flow charts and a list of activities, decision trees, hazard analyses, possible deviation and corrective action reports, planning of periodic auditing and or environmental assessment, additional regulation to improved decision-making. This study will describe existing food safety and international dairy and water safety legislation and norms and propose additional legislation if they are found deficient.

3. 4. 6 Plan of work

Figure 3.8 is a diagram showing the plan of work for this study. It indicated how HACCP and principles of environmental risk assessment will be used.

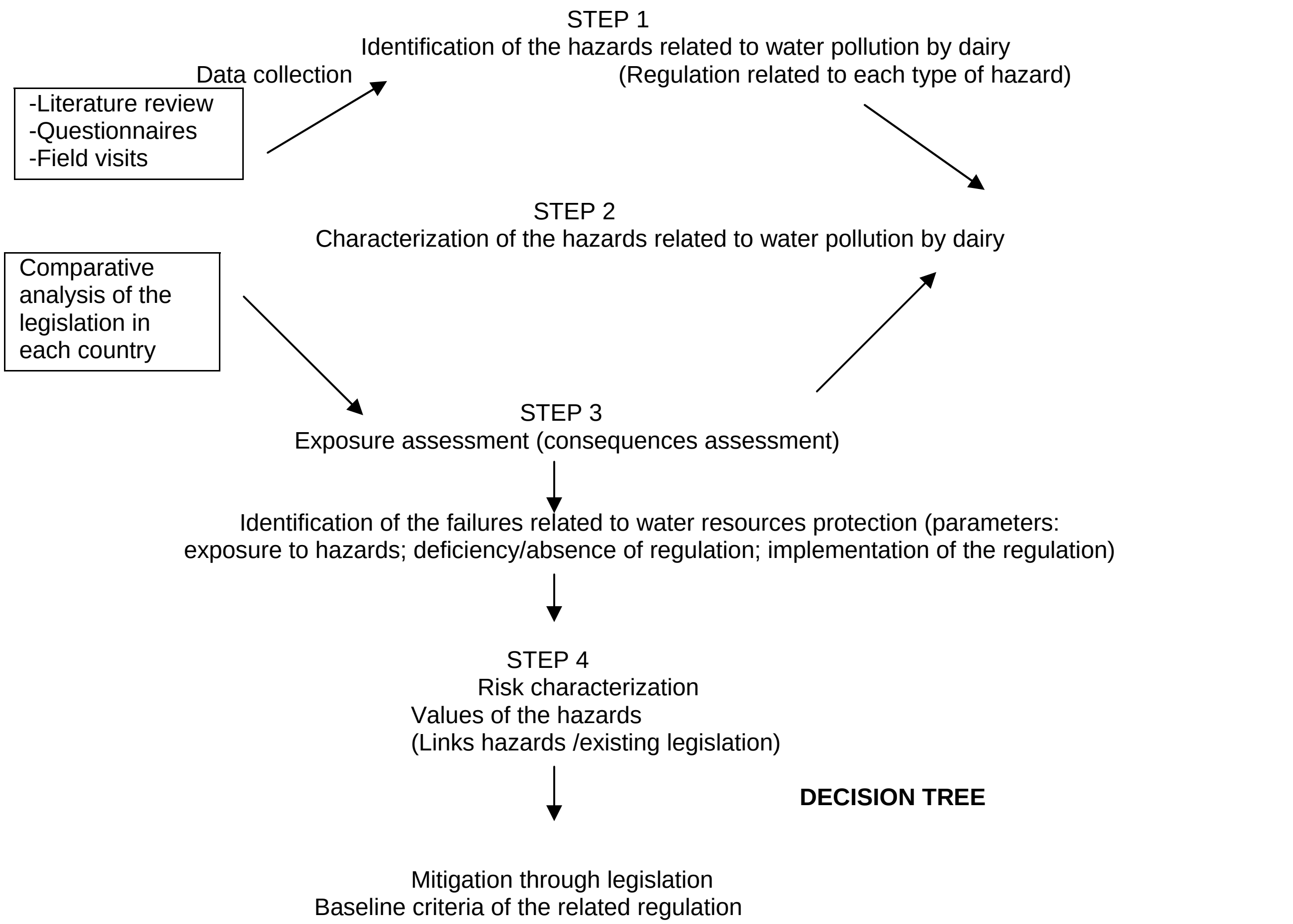


Figure 3.8: Plan of work for the study

CHAPTER 4

RESULTS

4.1 Introduction: outline of dairy farming systems in SA and in Benin.

The dairy farming systems practiced in SA and Benin are discussed in detail in this section. The farming systems have been described based on a critical literature review of dairy farming systems (see Chapter 2 for overall literature review) combined with personal observations and semi-informal participatory interviews conducted with farmers in both SA and Benin.

4.1.1 Dairy farming systems in SA

Dairy breeds were introduced in SA centuries ago. SA has a dual economy represented by world-class commercial dairy farming systems, side-by-side with small–scale and traditional farming systems that market dairy products through informal channels. The characteristics of the dairy farming systems are summarized in Table 4.1. There are three types of commercial dairy farming systems in SA: extensive pasture grazing, semi-intensive and intensive production. Improved and exotic dairy breeds are used. Calves are weaned early, sometimes at birth. Production levels are similar to those in Europe and America (Casey & Maree, 1993; Giesecke *et al.,* 1994). The traditional dairy-farming system is practiced usually on communal ground or leased small - holdings, due to the previous home - land system. Various breeds of dual purpose and crossbred cows are used. There are minimal inputs with low production and calves are weaned late for sale (FAOSTAT, 2005 (c) and (d); Manzana, 2007, Prozesky *et al.*, 2003; SA Online, 2006). Commercial dairy production systems must implement all legislation on dairy production in order to be registered. Food processing plants are monitored and quality control done, in line with Codex and FAO guidelines for milk hygiene and processing (CAC, 1999; CAC, 2001; CAC, 2004; CAC, 2007(a); Collins 2004; FAO, 2002(a); FAO, 2004; FAO, 2005).

There is a strong relationship between the stakeholders in the chain through institutions such as the Milk Producers Organization (MPO) and the South African Milk Processors Organization (SAMPRO) (Burger, 2005 & 2006; Milk-SA website, 2007[10].

[10] http://www.melksa.co.za

The Dairy Standards Agency (DSA)[11] is a Section 21 Company that has as its aims:

- the improvement of the quality of milk and dairy products;
- monitoring the production of safe dairy products, using on-farm milk audits, coupled with HACCP in the commercial dairy processing industry to comply with legal standards; and
- regular communication with the state authorities as the official agency of the dairy industry regarding food safety and quality.

The characteristics and possible hazards associated with the informal/traditional dairy market that were investigated, are summarised in Table 4.1. All plates illustrating the commercial and the traditional farming systems in SA are included in Appendix 2.

Table 4.1: Summary of farming systems in SA from literature and observation (Casey and Maree, 1993; Manzana, 2007; Prozesky *et al*., 2003; Personal Observation L. Goutondji)

Farming system	Characteristics
Large-scale commercial	Intensive or semi-intensive > 250 cows. Milking by machine. Production > 20 L per day per cow. Health care by veterinarian. TB and CA free, vaccinated, dewormed and tick control minimal. High quality and quantity of balanced rations fed. Grazing on planted pasture or fed hay or TMR in barns. Manure removal system in place. Water used is of potable quality. Calves are weaned at birth. Sales of milk and dairy heifers. Dairy cows breeds *Holstein* and *Jersey, Ayreshire*. Strict control of import and export of cattle and dairy products. Some farms also have on-farm manufacturing capacity for dairy products and sell milk, yoghurt, cream directly to the public or retailers.
Small-scale commercial	<250 cows. Water from boreholes or municipality. Sales into informal or formal sector. Health care by private or state veterinarian. Milking by machine. TB and CA free, vaccinated, dewormed and tick control minimal. High quality and quantity of balanced rations fed. Grazing on planted pasture or fed concentrate and hay or Total Mixed Ration. Manure removal system in place. Water used is of potable quality. Calves weaned at birth. Sales of milk and dairy heifers. Dairy breeds cows like *Holstein* and *Jersey*, *Ayreshire.*
Informal small-scale	Mixed and dual-purpose cows, sell calves and milk. Hand milking. Milk sold informally. No private veterinary care, Vaccination, CA and TB testing by state veterinary services. Some intensive dairy farming in peri - urban areas and settlements. Calves sold at or before weaning. Water from boreholes, rain, rivers, streams, lakes and dams. Milked once or twice a day.
Communal/ traditional	Calves suckle from cow. Extensive grazing. No or little supplementation. Cows produce about 5 litres per day maximum. Calves sold at weaning. Milked once a day. Water from rives, dams and lakes.

*TMR- Total mixed rations

4.1. 2 Dairy farming systems in Benin

In Benin, there is an ancient tradition of dairy systems linked to the geo-climatic and socio cultural aspects. Traditional pastoralists (*Fulani* breeders) have been involved in dairy systems for many centuries. For a long time they have been the only stakeholders of the local dairy chain. Specialized local dairy breeds do not exist in Benin and livestock farming systems are traditional, extensive and

[11] http://www.dairystandard.co.za

multipurpose. Transhumance and agro-pastoral systems are an important feature. There are minimal inputs with low production and calves are weaned late for sale (Kees, 1996; MAEP, 2004; Ogodja, 1988).

Cattle farming is spread mainly across the North East (Alibori and Borgou - 69%), the North West *(Atacora* and *Donga* - 21%), and the Central (Zou and Collines - 5, 2%) parts of Benin. The North East has the largest number of cattle in the country (CIENI, 2004, DE, 2004, Kees, 1996).

Prior to 2000, dairy farming was not really considered to be a specific farming system different from cattle farming in general. Since 2000, however, the Government of Benin has implemented a policy to improve the approach to dairy farming, in three of the four state farms. Exotic dairy breeds have been introduced into the country and experiments are being conducted with local breeds to increase dairy production and improve the dairy chain. Feeding and herd management strategies, in line with the FAO Good Dairy Farming Practices guidelines have been introduced (FAO/IDF, 2004). Calves are weaned early under this system, in contrast to the late weaning practiced in the traditional system (MAEP/DE/ PDEIII, 2004(a) & (b)). The Republic of Benin is now committed to the development of the dairy sector through the Livestock Strategic Sectoral Action Plan (MAEP 2003; MAEP/DE/PD III, 2004(a) & (b)).

Seven traditional farmers (one transhumant, and six agro-pastoral dairy farmers), one state farm and one commercial farm, representing the dairy sector, were visited in Benin during July 2006, which is the end of the rainy season.

The traditional farms are located in the area of *Gogounou* (municipality of Kandi - Department of Alibori), which is one of the biggest dairy farming area in Benin. Six of the seven farmers interviewed were agro-pastoralists and one was a transhumant. The state farm at Kpinnou in the South West of Benin was considered to be representative of the four states dairy farms in Benin. The other three are located at Okpara in the Department of Borgou (North West Benin), MBetecoucou in the Central Zone and Samiondji in Central Benin. One private farm in the north of Benin at Kokoubou was also visited to represent the commercial dairy industry. Sedentary farming is not as common as agro-pastoral farming, although the management is similar. The sedentary farms do not move their cattle away from the homestead and have wells to provide water to several farms in a small area. They also have crop-lands. This farming system exists in the South of Benin and data on it was available in the literature and from personal observation (ABE/LABEE-DE, 2005; Akuesson, 2001; CIENI, 2004).
The dairy production systems in Benin are summarized in Table 4.2 below. Plates associated with farming systems in Benin can be seen in Appendix 2. Information related to legislation is in Appendix 3.

Table 4.2: Summary of farming systems in Benin from literature and observation (Kees, 1996; MAEP, 2004; Ogodja, 1988; Personal observation L.Goutondji).

Farming System	Characteristics
Transhumance	Traditional. Several herds move together with 60 to 80 animals per herd. Mixed breeds: *Fulani, Goudali, MBororo, Borgou.* Transport on foot for long distances during several months of the year. Multipurpose breeding for dairy, draft and meat. Health care with traditional medicine. Occasionally use stock remedies, usually bought on the illegal market. No withdrawal times observed for stock remedies or traditional remedies. No biosecurity practiced. Grazing on natural pasture. Minimal inputs with low production. Manual milking. Low production 0, 5 to 2 litres per cow/day. Informal sales of fresh unpasteurised milk, but not cheese. Calves weaned late for sale. Drinking and watering in rivers, lakes, boreholes, waterholes, dams. No environmental awareness. No awareness of food quality and safety.
Agro-pastoral	Local specific dairy breeds do not exist. However the *Borgou* breed is considered as the best potential producer. Multipurpose breeding in a camp owned by a breeder. About 50 -150 animals. Milk production 0, 5 -2 litres per cow/day and 2-4 litres per cow/day in the improved system. No biosecurity, but the surroundings of the camp are kept clean. No waste disposal. Generally organic waste. Owners are very careful about buying animals and use traditional medicines to treat cows (all farmers n=7) Occasionally use of registered livestock remedies and vaccines which are well-controlled by the State Veterinary Services who inform farmers about withdrawal times (100% of farmers interviewed). However an informal trade in drugs and parasiticides exists. Milk products are represented by traditional cheese and sour milk for commercial purpose. Withdrawal times not always observed for drugs in milk (five of the six traditional farmers questioned did not know about milk -withdrawal for drugs). Testing for BTB and Brucellosis is sporadic. Mastitis and footroot exist but are not a big problem. Ticks and worms are considered important by farmers, but controlled with parasiticides. Old and castrated males, old females are sold. Calves are weaned late. Natural pasture grazing and supplementation with salt. Manual milking with basic hygiene practices in place. Cleaning with natural sponge and untreated cold water. No use of detergents or soap, sand is used as a scourer to remove milk-stone and milk fat. Drinking and watering in rivers, waterholes, fountains and dams surrounding the farm for agro pastoral; wells exist for sedentary farmers. No adequate building for animals (night camps) No waste strategies and management No HACCP plan. Very poor awareness of food safety. Effects on the environment: No storage or recycling of waste. Urine and manure are spread along the path, on the pasture or the surrounding of the camp, or near the water points.
Sedentary	Very similar to agro-pastoral with the exception that cattle remain close to the homestead, water supplies for cattle are via a communal drinking; through close to a communal well that serves several small farms. Tethering of cattle may be used instead of free-range grazing with herdsmen, which is more common in agro-pastoral systems

Table 4.2 continued

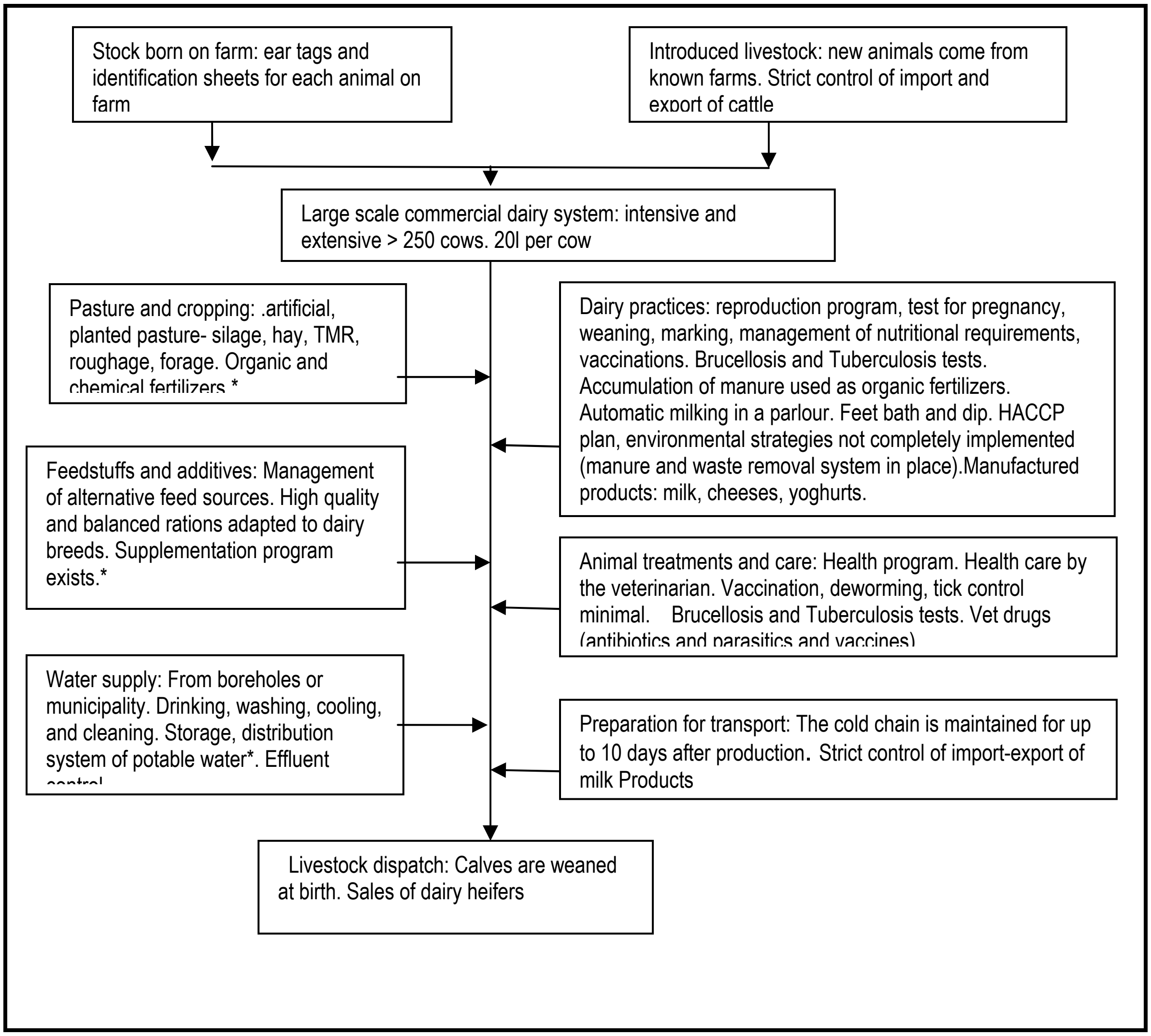
Farming system	Characteristics
State farms	An improved system has started with state farms since 2002, with the exotic dairy breads Gir and Girolando (*Bos indicus* breeds from Brazil). Traceability of animals is documented. Artificial insemination and cross-breeding is practiced. About 50-100 animals are kept per state farm. Production is up to 10 litres per cow/ day. There is regular health care and monitoring, with veterinary drugs, stock-remedies and vaccines. A foot bath is installed at the entrance to the farm for biosecurity. No Tuberculosis or Brucellosis tests are performed. Feeding and watering management is in line with GAP (FAO, 2004). Artificial and natural pastures and supplementation with limestone and vitamins. Potable water is used. Calves are weaned early. Production is recorded and improved. Manual milking is done in adequate buildings in line with international guidelines on milking hygiene, including cooling within a specified time (FAO website). Effects on the environment: Manure is gathered in a special place, dried and further spread on the pasture. However no statutory rate of spreading is followed. State farms are frequently far from the fields and watercourses to prevent pollution. No specific quality and environmental policies for waste disposal, but good waste-management practices exist in respect of the five first points of GAP.
Commercial private dairy farms	Similar to the state farms but are privately owned. They use local breeds, natural mating, and organic fertilizers. Dairy products are manufactured on-farm and include pasteurized milk and yogurts, flavoured or not flavoured and fresh pasteurized cream.

Flow charts associated with each of the above-described farming systems are shown in Section 4.2.

4.2 Flow charts of the different dairy systems in SA and Benin (HACCP steps 1 and 2)

Seven flow charts of dairy production as well as details on the activities related to each of the steps are given for each type of dairy farm in Figures 4.1, 4.2, 4.3, 4.4, 4.5, 4.6 and 4.7. Data related to these processes were obtained through informal questionnaires, observation during the visit and previous experience as a state veterinarian in Benin as well as a literature review.

* Note that the following inputs: animal feed, fertilizers and stock remedies used for cattle in SA are legal prerequisites in both commercial and other dairy systems as there is very good control of unregistered stock-feeds, remedies and fertilizers. By law, potable water is a prerequisite for commercial diary farms (DOH, 2003; NDA, 2006; NDA-SA, 1972).



<u>Figure 4.1</u>: Flowchart of large-scale commercial dairy production system in SA.
Key: * means that the quality control of these is a prerequisite governed by legislation.

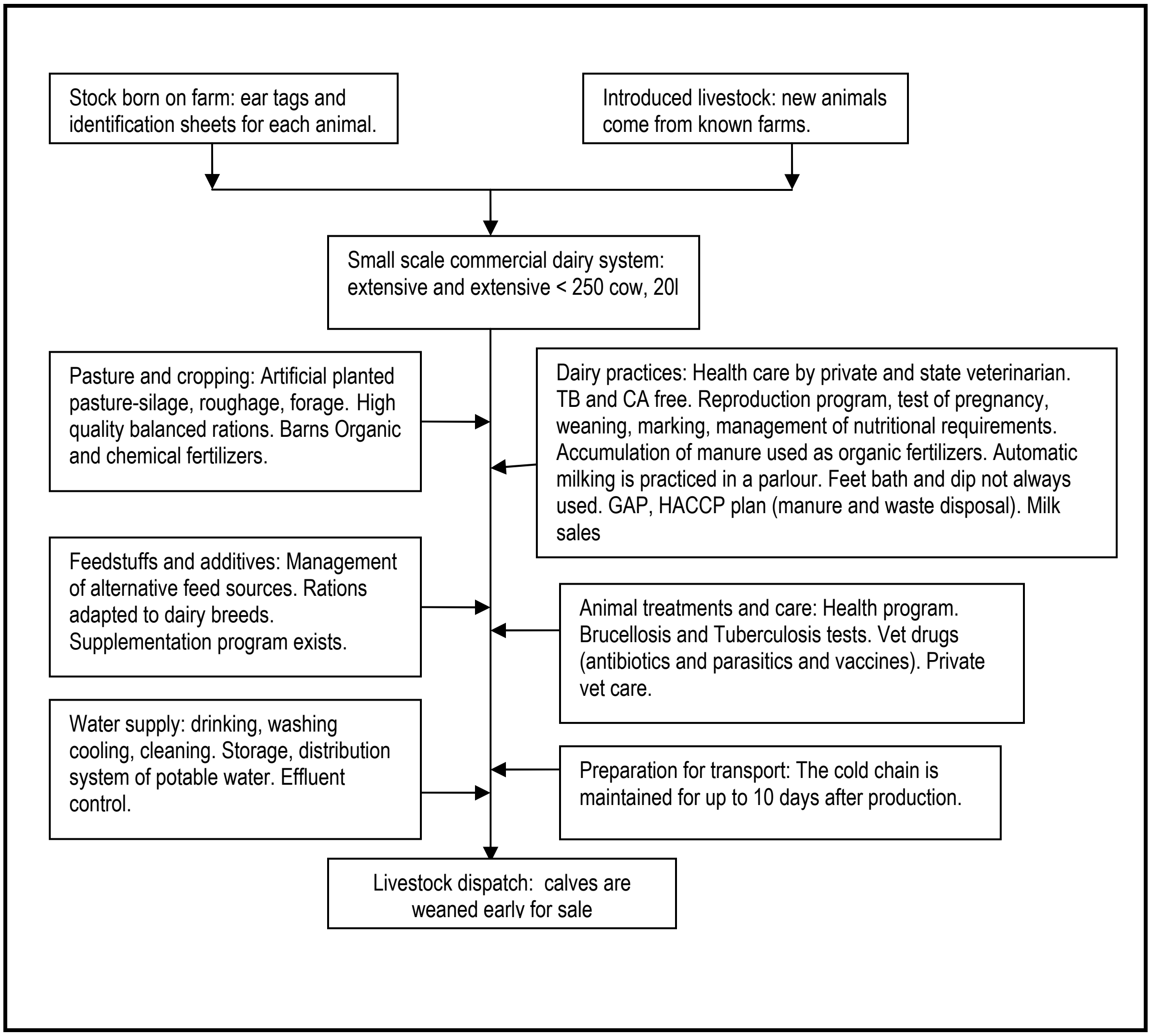


Figure 4.2: Flowchart of small-scale commercial dairy production system in SA.
Key: Quality control of fertilizers and food is covered by legislation: Prerequisite for HACCP.

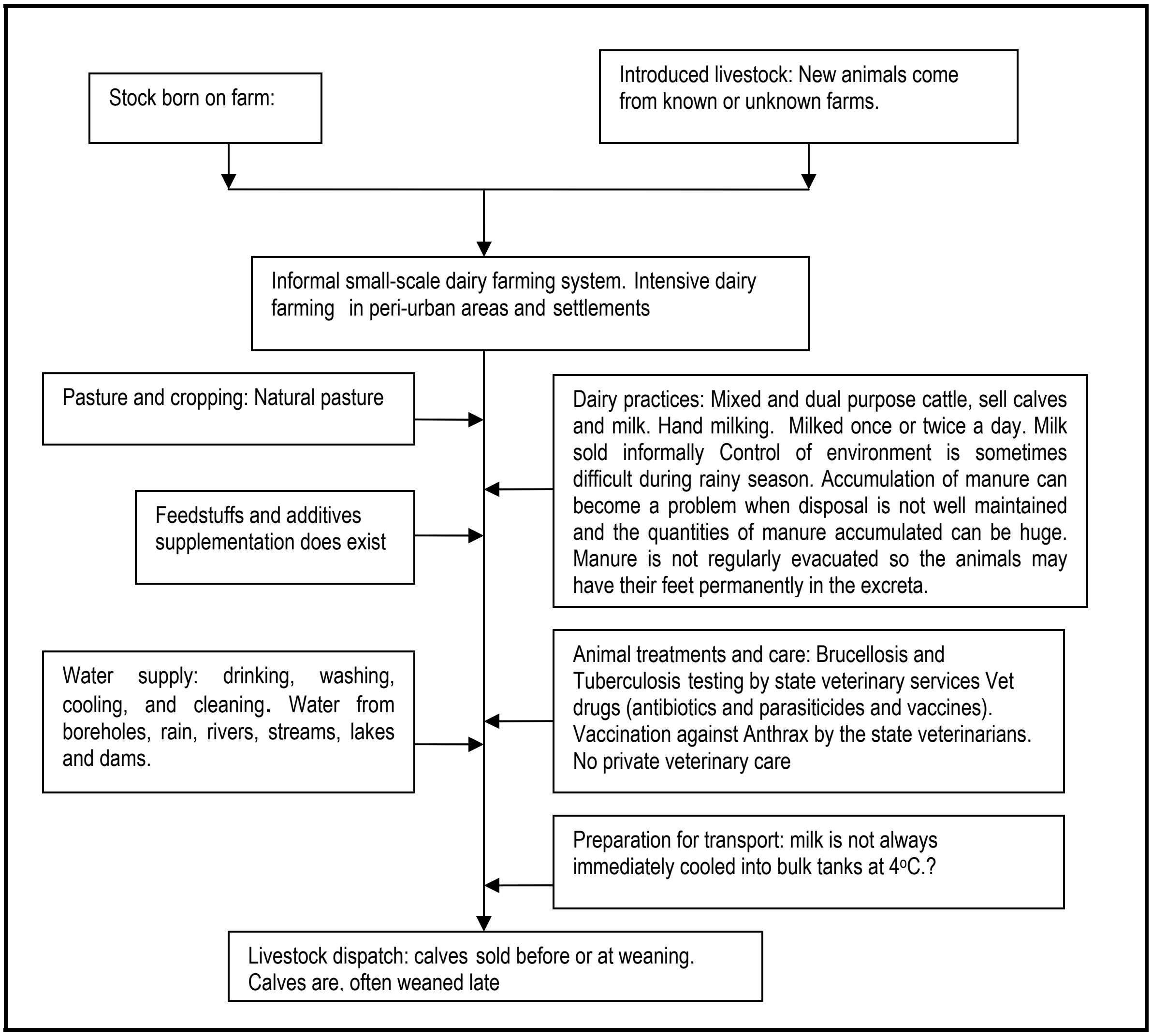


Figure 4.3: Flowchart of informal small-scale dairy farming

Key: Quality control of fertilizers and food is covered by legislation: Prerequisite for HACCP

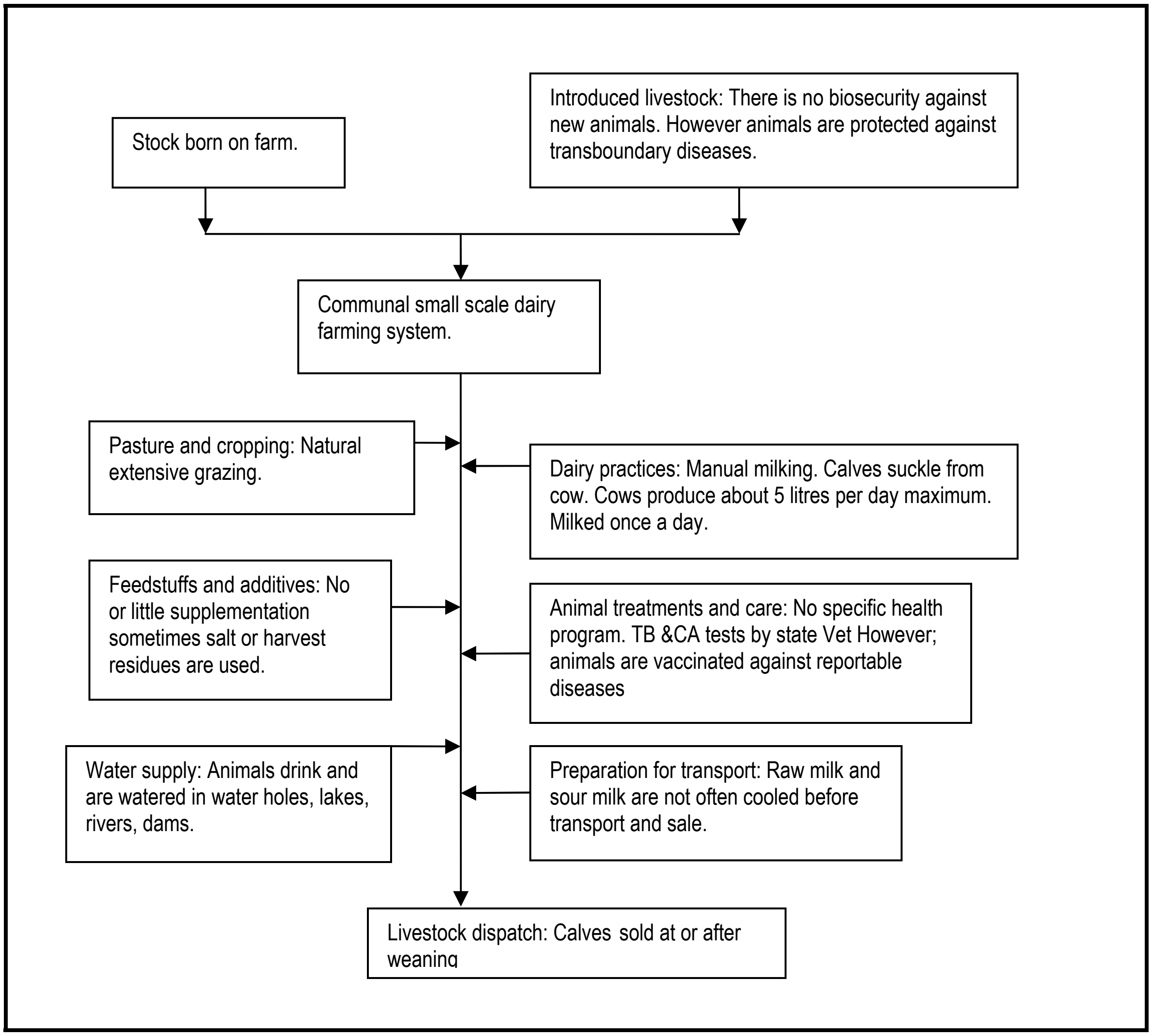
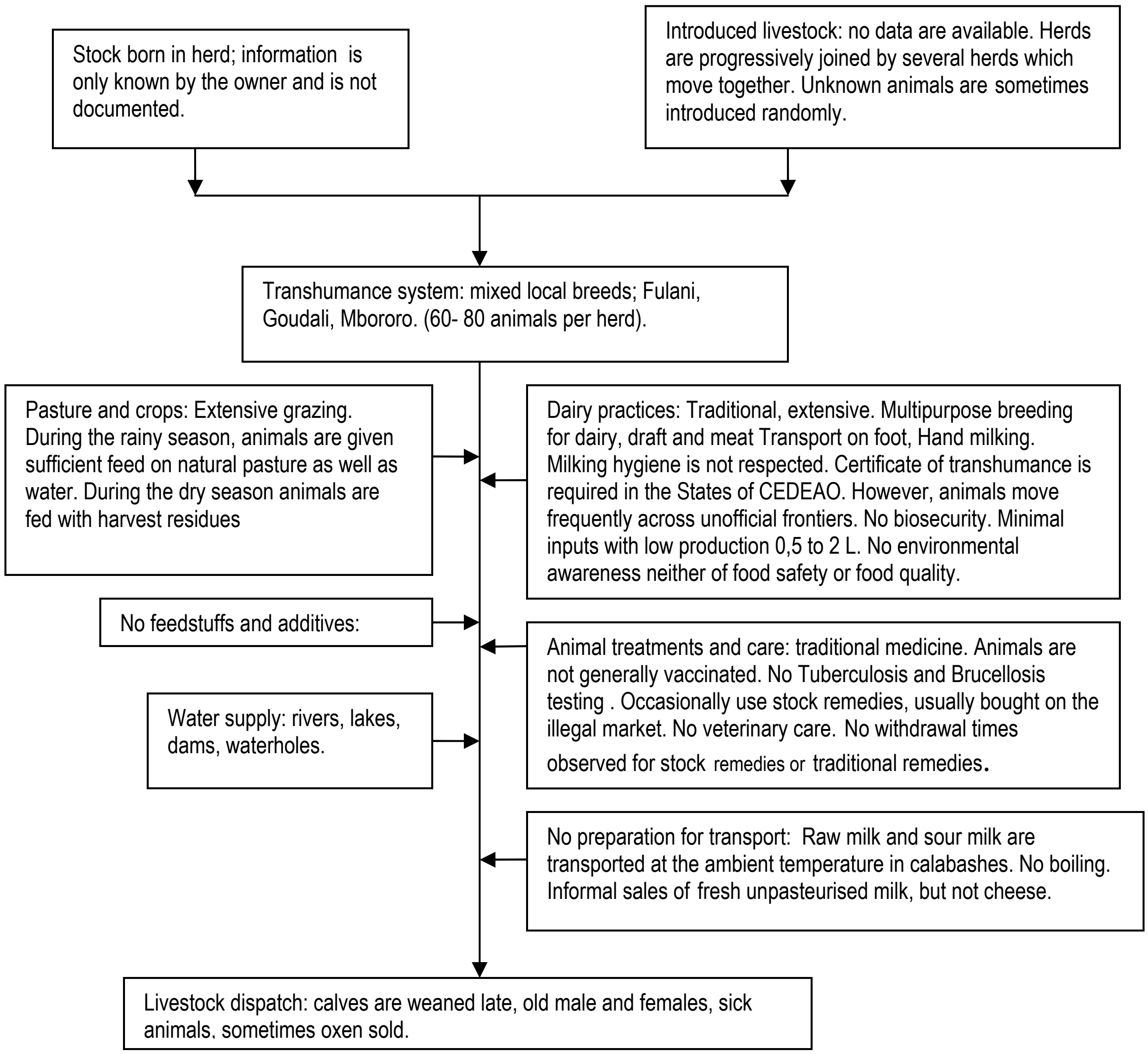


Figure 4.4: Flowchart of Communal small-scale dairy farming system in SA



<u>Figure 4.5</u>: Flowchart of transhumance dairy farming system in Benin

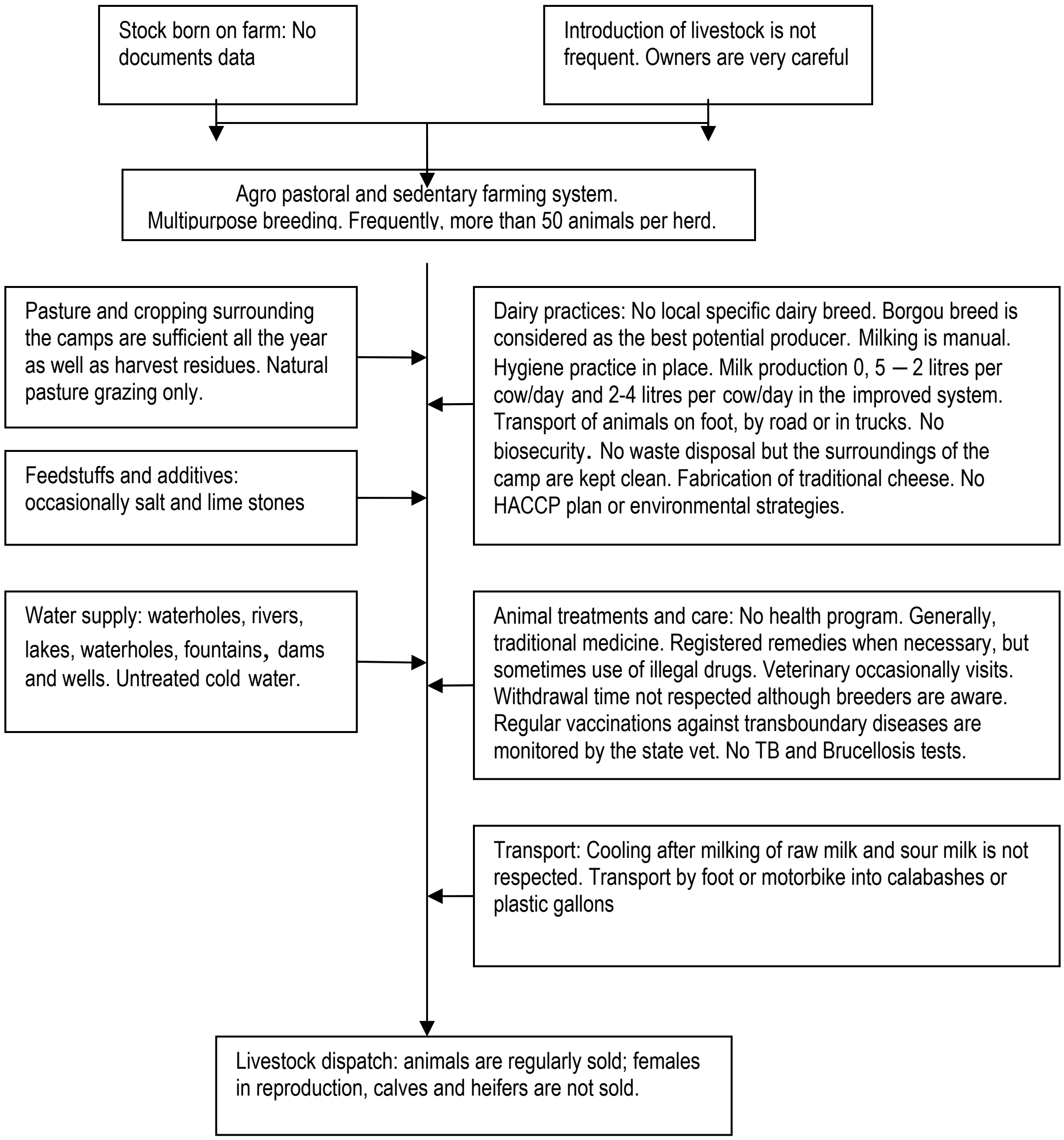


Figure 4.6: Flowchart of agro-pastoral and sedentary dairy/dual purpose farming system in Benin

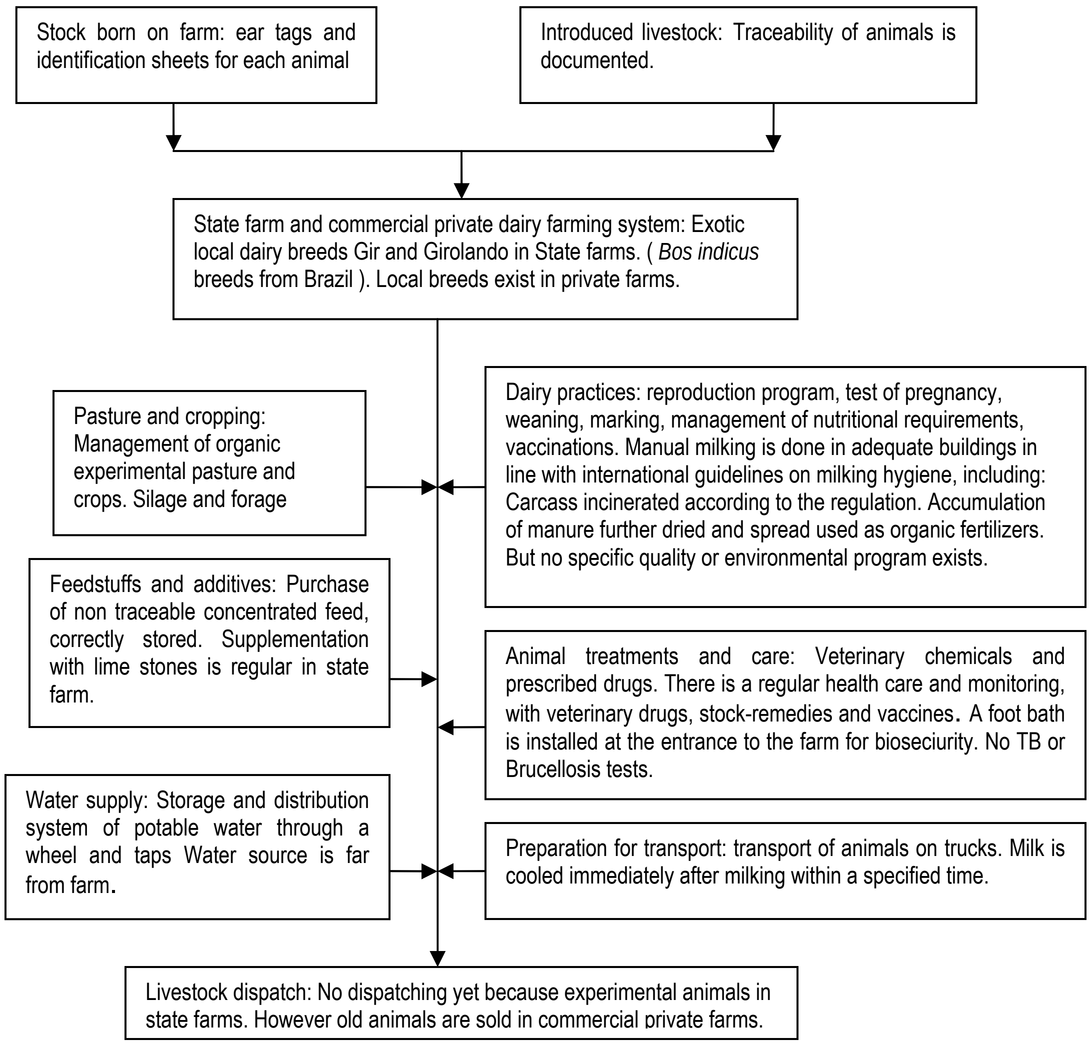


Figure 4.7: Flowchart of state farms and private improved farming systems in Benin

4.3 Process flow charts and list of activities related to dairy farming systems in SA and in Benin (HACCP steps 3 and 4)

The list of the activities associated to each step of the processes in different systems in each country is given in Tables 4.3 to 4.7 below. Eleven activities have been recorded along the dairy chain.

Table 4.3: Activities associated with the first three process steps (Animals born on farm, introduced livestock, production system) and related water use in dairy production process: flow diagram for each country (Farming systems F1 to F7 as described previously for SA and Benin) (Modified after the template of Horchner *et al*., 2006).

Process steps	Activities associated with this step	Water use	Specific dairy farm systems
1. Animals born on farm	- Identification and traceability: ear tags. Identification sheets -Fire marks, ear cuts	_	-Individual or grouped: F1.F2, F3-F4, F5, F6, F7.
2.Introduced livestock	-Purchase or obtain animals -Reception of animals -Identification and traceability of animals -Animals introduced randomly	_	- F3, F4, F5, F6, F7 - Idem a part of F4 - F1, F2, F7 - F3, F4, F5, F6: Identification only. - F4, F5
3.Production system	-Historical and land use -Contaminants from external sources -Intensive/ extensive dairy system -Quality and environmental strategies and policies	_	-F4, F5, F6 -F1, F7? Possible range of system for each country

KEY
F1: Large scale Commercial dairy system in SA
F2: Small scale commercial dairy system in SA
F3: Informal small scale dairy system in SA
F4: Communal small scale dairy system in SA
F5: Transhumance system in Benin
F6: Agro pastoral and sedentary system and private improved system farms
F7: State farms
? : Indicates uncertainties and /or lack of accurate data

Table 4.4: Activities associated with the fourth process step (Husbandry Practices) and related water use in dairy production process: flow diagram for each country (Farming systems F1 to F7 as described previously for SA and Benin) (Template after Horchner *et al*., 2006).

Process steps	Activities associated with this step	Water use	Specific dairy farm systems
4.Husbandry practices	- Mating - breeding and reproduction, culling - program/pregnancy testing	_ _ _	- F1, F2, F3, F6, F7 - F1, F2 and F7 Variable use of artificial insemination. Natural crossing
	-Weaning -Marking -Washing and cleaning of equipments	_ _ +	- Early for F1, F2) and F7: late for F3, }F4, F5 F6
	- Milking hygiene(udder preparation, equipment, housing and milking area, parlour , milkers)	+	Manual for F3, F4, F5, F6 and F7; Automatic for F1and F2
	-Dairy products processes -Movements on farm/between herds, camps or farms -Management of nutritional requirements	- _ +	
	-Animal health program: dipping, injecting, vaccinating, microbiological tests	+ +	- Exists for F1, F2 and F7. occasional microbiological tests for F7
	-Carcass disposal -Manure disposal	+ +	F1, F2,and F7 F1, F2,and F7

KEY

F1: Large scale Commercial dairy system in SA
F2: Small scale commercial dairy system in SA
F3: Informal small scale dairy system in SA
F4: Communal small scale dairy system in SA
F5: Transhumance system in Benin
F6: Agro pastoral and sedentary system and private improved system farms
F7: State farms
? : Indicates uncertainties and /or lack of accurate data

Table 4.5: Activities associated with the fifth and sixth process steps (Pasture and cropping; Feedstuffs and additives) and related water use in dairy production: process flow diagram for each country (Farming systems F1 to F7 as described previously for SA and Benin) (Template after Horchner *et al.*, 2006).

Process steps	Activities associated with this step	Water use	Specific dairy farm systems
5.Pasture and crop residues and also zero grazing (barns) - manure disposal	-Management of pasture and /or crop quality -Purchase- reception-storage- preparation of pasture and/or crop chemicals	+ + +	-F1,F2, F7 -F1,F2 - F1, F2
	-Application of pasture and /or crop chemicals -Disposal of chemicals -Identification and traceability of treated pastures and or crops	_ _ _	-F1, F2 -F1, F2, F7
	-Manage withholding periods	-	- F1, F2, F7
6. Feedstuffs and additives	- Management of alternative feed sources -Selection of feed type -Purchase - reception - identification and traceability - storage and treatment of feed.		-F1, F2, F3 - - F1, F2, F3, F4. F5, F6
	-Preparation of ration -Distribution of feedstuffs -Feed disposal		- F1, F2 -F1, F2, F3? F7? -F1, F2

KEY
F1: Large scale Commercial dairy system in SA
F2: Small scale commercial dairy system in SA
F3: Informal small scale dairy system in SA
F4: Communal small scale dairy system in SA
F5: Transhumance system in Benin
F6: Agro pastoral and sedentary system and private improved system farms
F7: State farms
? : Indicates uncertainties and /or lack of accurate data

<u>Table 4.6</u>: Activities associated with the seventh step and related water use in dairy production process: flow diagram for each country (Farming systems F1 to F7 as described previously for SA and Benin) (Template after Horchner *et al*., 2006).

Process steps	Activities associated with this step	Water use	Specific dairy farm systems
7. Water supply	-Water source	+	-Boreholes (F1, F2), -Lakes, rivers dams, wells (F3, F4, F5, F6, F7)
	-Control of water quality/contamination (chemical contamination, C. due to farming practices		-Potable water: F1, F2, F3, F7 -Polluted water: F4, F5, F6
	-Storage -Distribution system	 +	- Water holes, wells, dams, rivers' catchments, watering places -Directly in the sources, water taps, pipes, sails (F4, F5, F6) -Water pipes (F1, F2, F3, F7)
	-Control of effluents - Wastewater and other liquid wastes management	-	-F1?

KEY

F1: Large scale Commercial dairy system in SA
F2: Small scale commercial dairy system in SA
F3: Informal small scale dairy system in SA
F4: Communal small scale dairy system in SA
F5: Transhumance system in Benin
F6: Agro pastoral and sedentary system and private improved system farms
F7: State farms
? : Indicates uncertainties and /or lack of accurate data

<u>Table 4.7</u>: Activities associated with the eighth step and related water use in dairy production process flow diagram for each country (Farming systems F1 to F7 as described previously for SA and Benin) (Template after Horchner *et al.,* 2006).

Process steps	Activities associated with this step	Water use	Specific dairy farm systems
8. Animal treatment and care (welfare)	-Control introduction of animals of known health status onto the farm		- F1, F2, F7
	-Dairy production enhancers		- F1 only
	-Agricultural and veterinary prescribed drugs and chemicals	+	-F1, F2, F7;always F2, F3, F4, F5, F6 not always
	-Security of biodiversity		-F1,F2, F7
	-Diseases and parasites controls		- F1, F2, F7
	-Secure boundaries onto the farm: flies, ticks, worms -Clean equipment	 +	-F1, F2, F7 always - F1, F2, F7 always
	-Isolation of sick animals		- F1, F2, F7; always -F3, F4, F5, F6 not always
	-Management of zoo noses		
	-Purchase, reception, storage and preparation of chemicals	+	- F1, F2, F7; always -F2, F3, F4, F5, F6 not always
	-Approval for the use/of label use -Appropriate training of people -Competent and registered professionals - Identification and traceability of treated animals		- F1, F2, F7; always F3, F4, F5, F6 not always - As above

KEY
F1: Large scale Commercial dairy system in SA
F2: Small scale commercial dairy system in SA
F3: Informal small scale dairy system in SA
F4: Communal small scale dairy system in SA
F5: Transhumance system in Benin
F6: Agro pastoral and sedentary system and private improved system farms
F7: State farms
? : Indicates uncertainties and /or lack of accurate data

Table 4.8: Activities associated with the ninth and tenth) and related water use in dairy production process flow diagram for each country: (Farming systems F1 to F7 as described previously for SA and Benin) (Template after Horchner et al., 2006)

Process steps	Activities associated with this step	Water use	Specific dairy farm systems
9.Preparation for transport of milk and dairy products	-Cooling of milk in tanks (time, cleanness of milk storage area, equipment. Pasteurization -Safe access for bulk milk collection	+	-F1, F2,F7 only -F1, F2, F7 only
10. Livestock dispatch	-Culling of old or sick animals -Calves sale after late weaning -Calves sale after early weaning -Old or sick animals sale -Bulls stay in the herd -Heifers -Cows		-All farms -F4, F5, F6 -F1, F2, F3, F7 -All farms -F4, F5, F6

KEY
F1: Large scale Commercial dairy system in SA
F2: Small scale commercial dairy system in SA
F3: Informal small scale dairy system in SA
F4: Communal small scale dairy system in SA
F5: Transhumance system in Benin
F6: Agro pastoral and sedentary system and private improved system farms
F7: State farms
? : Indicates uncertainties and/or lack of accurate data

Table 4.9: Activities associated with the eleventh step and related water use in dairy production process flow diagram for each country: (Farming systems F1 to F7 as described previously for SA and Benin) (After Horchner *et al.*, 2006).

Process steps	Activities associated with this step	Water use	Specific dairy farm systems
11.Environmental care	-Storage of wastes: Inspection of signs of leaks, failures; plastics silage wraps.		- F1, F3, F7 only
	-Management of pastures to avoid effluents runoff by spreading farm manures in accordance with local conditions (conditions and soil types, buffer zones, identification of areas on-farm with high risk of pollution, statutory rates of application of manure spreading, waste management plan).		- F1, F3, F7 only At a certain level. Not completely implemented
	-Contention of dairy runoff on-farm (locate, store and adequate use of storage facilities for polluting substances)		-F1, F3, F7 only At a certain level. Not completely implemented
	-Use chemicals appropriately to avoid combination of the local environment (ensure safe and secure storage away from the dairy; registered chemicals; safe disposal of expired or defective chemicals		-F1, F3, F7 only
	-Ensure overall appearance of the dairying operations appropriate for a facility in which high-quality food is harvested (cleanness of farm surrounding, sheds; access roads free of effluents)		- F1, F3, F7 only
	-Application and disposal of chemicals		F1, F3, F7 only At a certain level. Not completely implemented

KEY
F1: Large scale Commercial dairy system in SA
F2: Small scale commercial dairy system in SA
F3: Informal small scale dairy system in SA
F4: Communal small scale dairy system in SA
F5: Transhumance system in Benin
F6: Agro pastoral and sedentary system and private improved s system farms
F7: State farms
? : Indicates uncertainties and /or lack of accurate data

- The list of the process steps and the activities in each type of dairy farming system indicates two groups:

In group 1, represented by F1, F2, and F7, the steps and the related activities are conducted with the same procedures although at different levels importance. Good dairy practices as prescribed by the FAO guide are followed. The differences observed in the animal health care program, the pasture and cropping, feedstuffs and additives are not qualitatively significant.

- Group 2 represented by F3, F4, F5, and F6 is characterized by traditional dairy practices.

Important differences between the two groups above or inside each group were observed with regard to water supply, disposal of waste and milking routines:

- o Potable water is supplied to cattle in systems F1, F2 and F7.
- o Water is supplied mainly from bore-holes and rivers in systems F3, F4, F5 and F6.
- o Machine milking in hygienic milking parlours are used in F1, F2,
- o Manual milking is practiced in systems F3, F4, F5, F6 and F7.
- o Manure and waste disposal is mechanized and formalized in F1 and F2.
- o Waste disposal methods are formalized in F7.
- o Manure and waste disposal is informal and random, or does not exist in F3, F4, F5 and F6.
- o Use and disposal of stock remedies (including antibiotics) and agricultural chemicals (parasites control) is formalized in F1, F2 and F7.
- o Use and disposal of stock remedies (including antibiotics) and agricultural chemicals (parasite control) is not formalized in F3, F4, F5 and F6.

4. 4 Identification of potential hazards at farm level (HACCP Step 6/principle 1)

Potential hazards connected with livestock farming in general and specifically dairy production, were identified through literature review and the above overview of the different farming systems, existing in both countries. A decision tree was developed according to the HACCP-based approach (CAC, 1999) to construct a risk profile of the hazards in water resources, related to each of the activities of each specific farming system in the different countries using a modification of the template developed by Horchner *et al., (*2006).

This decision tree concerns milk and dairy product safety as well as protection of water resources at farm level (Figure 4.8). The principles of Good Agricultural/farming Practice (GAP), Good Dairy Practice (GDP) and Good Hygiene Practice, including some of the Environmental risk assessment/water resources protection, are the basis of the assessment of the hazards identified (Tables 4.10, 4. 11 and 4.12). In line with HACCP, the standard groups of hazards (biological, chemical physical) can be applied to two main situations in the dairy sector.

These are:

1. Food safety hazards types related **directly** to animals and dairy products.
2. **Indirect** food safety hazards and environmental safety hazards related to the activities on the farm.

The identification of the hazards consists of the listing, the characterization and the effects of the potential hazards. Results of the hazard identification are based on the epidemiology of potentially hazardous agents in each country as well as the literature search related to the level of water contamination in each country (WHO, 2007; FAO, 2006(a); SA Online, 2004; MSP, 2005).

4. 4. 1 Decision tree for the identification of hazards

Five questions related to each potential hazard are the components of the decision-tree built in Figure 4.8. According to the answer Yes or No, a decision is made. The various decisions resulting from each question leads to a final decision.

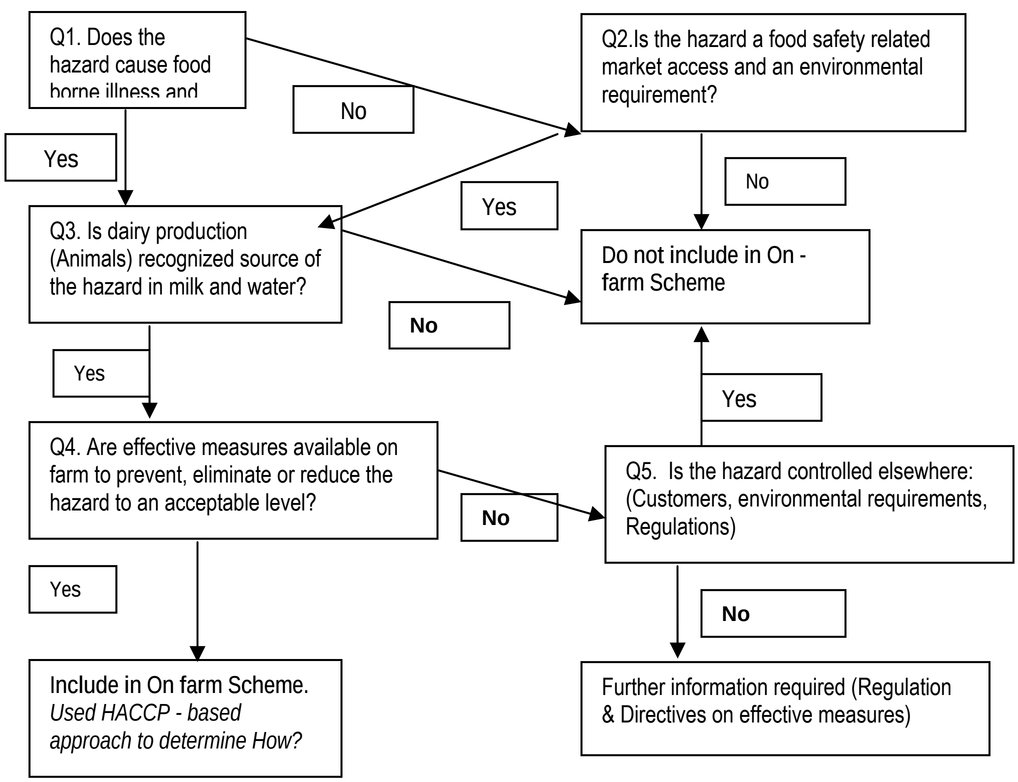


Figure 4.8: On-farm dairy products safety scheme hazard decision tree (Adapted from template of Horchner *et al*., 2006)

4.4. 2 List of identified potential hazards

The identification of potential hazards is established after having conducted a detailed hazard analysis overall, of dairy systems and the different steps of the activities within each type of dairy system. Almost thirty (30) hazards have been identified and listed in Tables 4.10, 4.11 and 4.12

Table 4.10: Biological hazards identification steps for milk and dairy production (dairy chain on farm level). (Template after Horchner *et al.*, 2006)

Hazard	Q1 Hazard for food and water? Y/N	Q2 Food safety market and water issues Y/N	Q3 Animals as primary source (A=animal P=processing) 	Q4 Effective measures on farm Y/N	Q5 Effectively controlled elsewhere? Y/N	Consider further in on-farm dairy product safety scheme Y/N
1.Biological 1.1 Microbiological *Campylobacter jejunil coli* *Coliforms* *E. coli(HEC)* *Salmonella enteridis & S typhymurium* *Listeria monocytogenes* *Staphyllococcus*	Y Y Y Y Y Y	Y Y Y Y Y Y	A/P A/P A A/P A P	}Y= only for F1, F2, }F7:cooling of milk }and Pasteurization, }N= for F3, F4, F5, }F6. Sour milk and }traditional cheese } manufactured in Benin	Y?=Laboratories controls(milk and water) in SA. Pasteurization in dairy factoriesF1, F2, and traditional cheeses F7 N(c) = in Benin	}Y= }Processing }controls }As above }Y in }Benin and F3
Antimicrobial resistant bacteria (hazard for F3, F4, F5 F6)	Y	Y	A/P	Y =withdrawal periods observed for antibiotics for F1, F2, F7. N(c) for F3. Not a recognized public health problem (c)		}Y in Benin }and F3
Mycobacterium bovis *Brucella melitensis* *Bacillus anthracis.* *Hazard for F3, F4,F5,F6) and at a lesser level F7*	Y Y Y	Y Y Y	A A A	} Y For F1 F2, F7only Tests for F1, F2, Regular vaccinations Herd inspection.	}N (c) for F3, F4, F5, F6, F7 }Y for F2 F2Quick Alert System (OIE)	Y for F3, F4, F5, F6, F7

a: Improves milking hygiene or dairy practices but not a CCP for microbial hazards arising on farm

c: No previous data available ?: Uncertainty

<u>Table 4.10</u>: Biological hazards identification steps for milk and dairy production (dairy chain on farm level). (Template after Horchner *et al.*, 2006)

Hazard	Q1 Hazard for food and water? Y/N	Q2 Food safety market and/l (water) issues Y/N	Q3 Animals as primary source (A=animal P=proces sing)	Q4 Effective measures on farm Y/N	Q5 Effectively controlled elsewhere? Y/N	Consider further in on-farm dairy product safety scheme Y/N
1.2Macrobiological CCBP Foot and Mouth disease Tuberculosis	N(c) N	Y Econo mic Issue s	A A A	Y Herds Inspections by the vet. regular vaccination	As above " "	N N Y
Mycotoxins Afflatoxin M1 *Hazards for F1, and F2)*	Y? Y	 Y Y	P(feed) P(feed)	Natural pasture. Not a recognized public health problem in dairy in Benin Y? = for F1 and F2 only. Stock feed controls control?(not specifically for Mycotoxins	N(c) N(c) Y=Feed programs and codes of practices (F1, F2, F7)	}Y for F1 }and F2
Parasites(Giardia, Fasciola, *Cryptosporidium spp* Taenia), Flies, ticks, ants cockroaches *Hazards for F3, F4, F5, F6)*	Y Y N	Y? Y?	A/P	Deworming, deeping, vermin control only for F1, F2, F7.	Laboratory analysis for F1, F2 Occasionally, analysis of samples	Y for F3, F4, F5, F6, F7

a: Improves milking hygiene or dairy practices but not a CCP for microbial hazards arising on farm

c: No previous data available ?: Uncertainty

<u>Table 4.11</u>: Physical hazard identification step for milk and dairy production (dairy chain at farm level)

Hazard	Q1 Hazard for food and water? Y/N	Q2 Food safety market and/ (water) issues Y/N	Q3 Animals as primary source (A=animal P=processing)	Q4 Effective measures on farm Y/N	Q5 Effectively controlled elsewhere ? Y/N	Consider further in on-farm dairy product safety scheme Y/N
2. Physical Udder injuries	Y ?	Y	A	Y=Good dairy practices but not always(milking hygiene, animal health care only for F1, F2, F7 Y= for F2, F4, F5, F6 Gentle manual milking Y?=welfare of animals Appropriate floors and adequate equipment only for F1, F2, F7 N= for F3, F4, F5, F6 Y?= Waste disposal (F1, F2, F7) N= for F3, F4, F5, F6	N(c)	Y for F1, F2
Blood	Y ?	Y	A		N(c)	Y for F1 and F2
Urine, Manure, Hair Mud, dirty water *Hazard for F3, F4, F5, F6) and for F1 and F2 if not controlled. Not a hazard for F7*	Y Y ? Y	Y Y Y Y	A A A P		N(c)	Y for all the dairy systems (Adequate waste management and recycling system)

a: Improves milking hygiene or dairy practices but not a CCP for microbial hazards arising on farm

c: No previous data available ?: Uncertainty

Table 4.12 Chemical hazards identification step for milk and dairy production (dairy chain on farm level)

Hazard	Q1 Hazard for food and water? Y/N	Q2 Food safety market and/I(water) issues Y/N	Q3 Animals as primary source (A=animal P=processin g)	Q4 Effective measures on farm Y/N	Q5 Effectively controlled elsewhere? Y/N	Consider further in on-farm dairy product safety scheme Y/N
3. Chemical and						
toxins	Y	Y	A	Y=Buffer areas	Y? Water	Y
Nitrates/Nitrogène	Y ?	Y?	A	between pasture and	resources	Y
Hormones*	Y ?	Y?	A	boreholes, adequate	analysed in SA;	Y
Parasiticides*	Y ?	N?	A	system of watering,	but not	
Vitamins*	Y	Y	A	watersheds for the	completely	Y
Antibiotics*	N	Y	A	animals. Controlled use	validated.	Y
Veterinary drugs*F1, F2				of vet chemicals for F1,	Effectivity of	
residues	Y	Y	P	F2, F7 only	other controls	Y ?
Detergents*	Y	Y?	P	N=Strict control and	to be	N
Disinfectants	N	N	P	management of liquid	confirmed.	N
Organic chlorides and				waste disposal for F1,	Control of	
chlorines	Y	Y	P	F2 not confirmed	biodiversity	?
				N= for F3, F4, F5, F6,	Samples tests	
Heavy metals (Pub	N?	Y	A?	F7	occasionally in	
*and Cu)	Y	Y	P		Benin.	Y
Dioxins	Y	Y	P			Y
Mycotoxins*F1, F2						
Processing* chemicals						

b: Improves environmental issues but not at the level of environmental policies or norms
c: No previous data available
?: Uncertainty

Characterization of the above hazards is detailed in section 4.4.3 and their effects are described in section 4. 4. 4 below.

4. 4. 3 Characterization of the hazards

The exact characterization of the hazards is complex, due to the number of parameters and variables that need to be considered and to the hazard itself, in different dairy farming systems and countries. Characterization of the hazard is usually conducted for each specific hazard for each specific situation. It is also called by some authors “risk or exposure assessment”, when it refer to microbiological hazards (FAO/WHO, 2002; McCrindle, 2003). It could be a quantitative estimation or a qualitative description. According to Steinfeld *et al*., (2006), the characteristics of the hazards generally should refer to the type or timing, the magnitude or the severity. However the specific parameters below are considered to determine the characteristics of the hazards.

These parameters are:

- the water use,
- the sources which are classified as point-sources and non-point sources,
- the pathways of water pollution which are described according to some variable,
- the mechanisms of water pollution which are direct or indirect.

The characterization of the hazards is also different for Benin and SA as well as for the different dairy farming systems classified and investigated in this study.

4. 4. 3. 1 Characterization of the hazards due to water pollution in SA

- Drinking:

  In F1, F2, F3, drinking is not a direct source of pollution as drinking water is generally of good quality, and is directly distributed to the animals. Water pollution by drinking is not a significant hazard for F1, F2 and F3 although the contamination of water can be indirect through point-sources as water boles, fountains and pipes when they are not well maintained.

  In F4, drinking water is a direct source of water pollution because animals are watered. Point-sources of pollution are watercourses and waterholes and physical hazards can be very important.

- Milk harvesting and dairy processes:

  In F1, F2, F3, the milking parlour is a point source of pollution. Indirect contamination of water occurs through ground and soil in the surroundings and the farms. Waste water borne, chemical and biological effluents, discarded milk, disinfectants and detergent also cause various hazards.

  Physical and biological hazards are very significant. The greater the numbers of animals, the higher the volume of waste, because high producing cows eat and drink more to produce larger volumes of milk.
  In system F4, the water source is indirectly polluted through soil layers and surface water by wastewater and discarded milk. However, the hazard is not significant, because relatively little waste is produced.

- Service or housing: (cleaning, washing, cooling facilities for animals or their products, treatment and care, calving, milking, waste disposal):

  Pollution due to service is more important (it is a greater potential hazard for water) in F1, F2, F3 because the volume of water used is also important. Housing can be a very important factor in water pollution by F1, F2 and F3 faming systems, when waste disposal is not well monitored.

  In F1, F2 and F3 farming systems, water sources can be directly polluted by sludge dams through waste water seeping down into soil. Thus chemical hazard is very significant. Contaminated forage, lakes, rivers, surface water in the environment surrounding the farm can become an indirect point-source of pollution. This hazard occurs when the pipes are not protected or if they leak and there is a build up of pollution around the pipe. The potential contaminants can come from wastewater, discarded milk, lime stones and foot baths containing Cu and Zn.

  Biological and frequently chemical hazards seem to be the most important in F1, F2, F3 farming systems because of the high population density of high producing cows.

  Chemical hazards are not too important in the F4 system because there is a lower population density of cows and a low-input-low output communal system, so the volumes are very low. Even the informal sector can only purchase registered stock remedies, parasiticides and disinfectants, so this becomes a well-controlled legal prerequisite for all livestock production in SA.

- Feed production:

  In F1, F2 and F3 farming systems, intensive artificial pasture and crop residues used as grazing land, are an indirect point source of pollution. Manure, fertilizers, pesticides and weed killers can pollute water sources through rain and runoff effluent. Chemical and biological hazards are very important for F1 and F2.
  Extensive natural pastures can also be used in F4 farming systems that are located in high rainfall areas, mainly along the east coast of SA. They are an indirect, non-point source of water pollution through runoffs and overland flows from grazing areas. Contamination of freshwater sources by manure and urine also occurs. The hazard related to pollution of surface and ground water is important in F1, F2, F3 farming system, as it linked to the high number and density of animals. The hazard is much lower in the F4 farming system.

The estimated highest risk (highest exposure assessment) for water pollution for each of the farming systems is shown in Tables 4.13 (SA) and 4.14 (Benin) below.

Table 4.13 South African dairy farming systems: Relevant sources, mechanisms and pathways for water pollution (hazards ranked in order of importance 1, 2, 3 etc)

Sources (point and non point)	Pathways	Mechanisms (Direct or indirect)	Significant hazard	Farming system
Drinking water: point source	1. Waste water 2. boreholes, fountains - pipes 3. natural water sources	Indirect: into surface and ground water	1. Physical 2. Biological 3. Chemical hazard Not important	F1, F2, F3
Drinking water: point source	Trampling, urination, defecation in natural water courses and water holes.	Direct: Livestock waste, manure, urine, deposition of faecal material into fresh water. Contamination of surface water	3. Physical 2. Chemical 1. Biological Very important	F4
Milking parlour: point source	1.Waste-water borne chemical and biological effluent 2.Discarded milk 3.Disinfectants and detergent	Indirect Lime stones, foot bath wastewater. Pipes	1. Biological 2. Not significant Physical 3. Chemical Important	F1, F2, F3
Manual milking area. Non point source	1.Waste water 2.Discarded milk	Indirect : Soil layers, surface water	1.Biological 1.Physical Not important?	F4
Housing and environmental care: point-source of pollution	1.Manure (Urea and K) 2. Urine (Nitrates and K) 3. Dirty bedding (Physical) 4. Feed residues	Indirect: Water used to flush housing. Runoffs from farms or overland flows. Contamination of freshwater sources by manure and wastewater containing detergents, drugs residues and antiseptics. Manure and urine pollutes surface and ground water.	1.Biological 2.Physical 3 Chemical hazards are important when there is no liquid and solid waste disposal and when the ground and the floor is not adequate –Manure buildup	F4 is not concerned by chemical hazards
Housing and environmental care: point-source of pollution	Waste water	Direct: Sludge dam through waste water seeping down into soil	1.Biological 2.Physical 3.Chemical Very important	F1, F2, F3
Intensive, artificial pasture: Point-source of pollution	1. Manure (Urea, K) Fertilizer (Phosphates) Pesticides and weed killers	Indirect 1. Rain 2. Runoff effluent	1. Physical 2. Chemical 3. Biological important	F1, F2, F3
Natural pasture: non-point sources of pollution	Manure and urine	Indirect: Runoffs from overland flows from grazing areas. Contamination of freshwater sources by manure and urine. Pollution of surface and ground water	3. Chemical hazard are important for F1, F2?	F1, F2, F3
			1. Biological, physical and chemical Not important	F4

F1: Large scale dairy farming system
F2: Small scale dairy farming system
F3: Informal small scale dairy system in SA
F4: Communal small scale dairy system in SA
? : Indicates uncertainties and /or lack of accurate data

Importance of the hazards:
1 Not very important
2 Fairly important
3 Very important

4.4.3.2 Characterization of the hazards due to water pollution in Benin

- Drinking

  In F5 and F6 farming systems, drinking water, represented by water courses, rivers, lakes, dams, and waterholes, are point sources of water pollution. Lying or standing in the water, trampling, urination, or defecation in natural water sources, while animals are drinking lead to pollution. The risk of pollution is higher when animals are numerous, such as when a large herd remains in one place for some time. Water sources can be directly contaminated by the presence of the herd and physical, chemical and biological hazards are very important. Physical hazards such as faeces, hair, abortus material or carcasses of dead cattle, can be major hazards. Biological and chemical hazards might also come from manure and urine.

  In the case of the F7 farming system the probability of the pollution occurring while animals are drinking is very low, because potable water is distributed directly to drinking troughs from boreholes or fountains. Indirect pollution might occur through waste water getting into underground water, boreholes and fountains.

- Milk harvesting and dairy processes:

  In the F5 and F6 farming systems, animals are milked once to twice a day and produce 2, 5 to 4 l per day. Cattle are milked outside or in mud-floored dairies In the F7 system; animals are milked twice a day and produce 7L to 10 L. The floors are of cement and the runoff is more controlled. However, the hazard is probably more important than that found in F5 and F6 as there is a higher stocking density and the milk productions (as well as feed consumption, faeces and urine) is higher.

  The milking area could be a point source of indirect pollution by waste water and discarded milk. Indirect pollution might occur through soil layers in the paddocks and enter the underground water table or surface water.

- Service or housing

  In farming system F5, housing is a non point source of pollution. Contamination is indirect and hazards are not significant because herds are always moving.

  In farming system F6, the probability for the hazard to occur is higher because in agro-pastoral and sedentary farming systems, animals stay in the same area; biological and physical hazards might also be important when there is not an adequate health program and waste disposal. In Benin, stock-remedies are not always well controlled and may therefore pose a hazard to the environment if unregistered drugs, insecticides, parasitizes are disinfectants and detergents used.

Chemical hazards should be less important in F5 and F6 because there is a very low input of stock remedies in these systems.

In F7, biological and physical hazards to water by manure, urine, dirty bedding, feed residues and other solid and liquid wastes should be lower than in F5 and F6 farming systems because animals' health is well monitored and waste disposal is controlled; Housing and service is conducted according to the FAO guide to Good Dairy Practices (FAO/IDF, 2004). Intensity of chemical hazards is likely to be higher because stock remedies are regularly used and pollution due to service can be more important because the volume of water used is also important.

Indirect contamination of surface and ground water might occur, but there is a high uncertainty because the farms are situated far from potable water sources. However the lack of a specific environmental program could be factor increasing the risk of water pollution.

- Feed production:

  In F5 and F6, animals are fed on natural pasture; thus there is no feed production and then no potential hazard. However, the likelihood of a hazard occurring varies with the stocking density and the movement of herds on natural pasture. It might be higher in farming system F5 and F6 if animals are very numerous in a given area.

  In farming system F7, feed production might be an important source because manure is reused for organic fertilization. This may leach into the water supplies, causing biological hazards, such as a build-up of coliforms. In the Northern part of Benin, crops are chemically fertilized. Harvest residues are used by the dairy cattle in system F5 and F6.The chemicals used for crop production may pollute water, but this would not be directly due to dairy production.

  In farming system F7, artificial pastures are still in the experimental stage. Although the likelihood of the hazard currently low, it might increase if specific monitoring is not put in place prior to expansion. Indirect pollution of water sources might occur through rainfall and runoffs from overland flows and grazing areas.

Table 4.14 Benin dairy farming systems: Relevant sources, mechanisms and pathways for water pollution (hazards listed in order of significance 1, 2, 3)

Sources (point and non point)	Mechanisms	Pathways (Direct or indirect)	Significant hazard	Farming system
Drinking water: point source	1. Waste water 1. fountains 1. natural water sources	Indirect: into surface and ground water	1. Physical biological and chemical hazard not significant	F7
Drinking water: point source	Trampling, urination, defecation in natural water courses and water holes.	Direct :Livestock waste, manure, urine Deposition of faecal material into fresh water. Contamination of surface water	3. Physical 2. Chemical and biological Very important .	F5, F6
Milking: Manual milking area	1. Waste water, foot bath wastewater 1. Discarded milk	Indirect. Soil layers, surface water	1. Biological 1. Physical Not important.	F5, F6, F7
Service: housing and environmental care: point source	1. Manure (Urea and K) 2. Urine (Nitrates and K) 3. Dirty bedding (Physical) 4. Feed residues	Indirect: Water used to flush housing. Runoffs from farms or overland flows. Contamination of freshwater sources by manure and wastewater containing detergents, drugs residues and antiseptics. Manure and urine pollutes surface and ground water.	1. Biological 2. Physical 2. chemical Fairly important, because of low number of animals but could be significant because there is no environmental program	F7
Housing: Non point source	Manure and urine	Indirect : Runoff from camps and farms Manure and urine pollute surface and ground water	1. Biological 2. Physical Fairly important	F5, F6
Feed production: Intensive, artificial pasture: Point-source of pollution	1.Manure (Urea, K) Fertilizer (Phosphates) Pesticides and weed killers	Indirect 1. Rain 2. Runoff effluent	1. Physical 1. Chemical 1. Biological Not important. There are only experimental artificial pasture in place	F7
Feeding: Natural pasture: non-point sources of pollution	Manure and urine	Indirect: Runoffs from overland flows from grazing areas. Contamination of freshwater sources by manure and urine. Pollution of surface and ground water	1. Biological, physical and chemical Not important.	F5, F6, F7

F5: Transhumance system in Benin
F6: Agro pastoral and sedentary farming system
F7: State farms and private improved system farms
? : Indicates uncertainties and /or lack of accurate data

Significance of the hazard:
1: Not important; 2: Fairly important;
3: Very important

4.4.3.3 Qualitative description of the likelihood and the magnitude of the hazards

The potential hazards vary in intensity in each type of farming system according to the parameters of water use, the sources, mechanisms and pathways of water pollution,. Consequently the magnitude of the risk is also variable.

Water use in dairy farms can be described through an overview of the most important steps of the dairy production and processes: drinking, service, milk harvesting and dairy processing and feed production. The quantity varies according to whether the farming system is traditional or modern, extensive or intensive, manual or automatic with milking machine. The quantity of water used is also closely bound to the number of animals and the breed (Lievaart *et al.*, 2005).

In commercial intensive farming systems represented by F1, F2, F3 in SA and F7 in Benin, water use is very important at all the steps of the dairy production and process. The most important hazards issue from milking and housing and at a lower level from pasture.

Water use is higher in F1 and F2 because of the number of animals and also because of the breeds. In F1, F2 and F3 in SA, European dairy breeds are milked two or three times a day and produce about 30 liters per milking. Milk production is also a factor, with production between 20 and 35 litres per cow per day (Giessecke *et al., 1994)*. In F7, however, local breeds or crossed-breed cows produce 2, 5 to 4 L and 7 to 10 L. Water use is then lower.

Physical hazards are not potentially very important because animals are watered from specific water fountains in Benin and get their drinking water from troughs. The risk of water being polluted by physical components through this way is low, except for leaks. It is probably higher in F3 where cows drink from waterholes (see earlier).

Chemical and physical hazards are more important in commercial systems. Surface and groundwater in F1 and F2 and to some extent F3 are threatened when there is no recycling or lack of adequate waste management. The hazard concerns nitrates and nitrogen coming from manure and urine, as well as total organic carbon. Heavy metals (Cu and Zn), detergents, drugs residues (antibiotics, antiparasitics) can be found in milk, urine and faeces which could enter waste-water runoff from the dairy.

In traditional farming systems represented by F4, F5 and F6, the most significant hazards emanate from animals drinking from surface water and at a lower level during grazing activities on natural pasture (Dudez & Broutin, 2003).

Water use is lower in F6, F5 and F4 because the system is traditional. Cows do not produce a high volume of milk and they are watered according to the availability of water. Physical hazards can be very important because the physical characteristics of water can be quickly adulterated when herds enter the area.

Biological hazards can also be significant when the same source of water is used by many animals. When animals' health is not well monitored, water can be contaminated by carcasses, enteric bacteria (coliforms), pathogens and endoparasites. In addition, high nitrates and potassium can lead to eutrophication, where algae overgrow the surface of the water and deplete it of oxygen, leading to death of aqueous flora and fauna.

As noted previously, chemical pollution, except for nitrates and potassium due to faeces and urine, are not important in low-input traditional farming systems in either SA or Benin.

- **Biological hazards** include bacteria due to water faecal contamination and discarded milk. The microbiological hazards are chiefly related to cows and dairy production. Microbiological hazards have a higher potential in F3, F4, F5, F6 because of low attention to milk hygiene and non-potable water supply. In F1, F2 and F7, there is a lower potential for biological hazards as GAP and GDP is applied to milk hygiene.

  Mycotoxins are potential hazards for F1 and F2 if large amounts of total mixed ration are fed, less so if they systems are based on pasture grazing. However in both cases, quality control of feed is implemented. In systems F3 and F4 in SA, because of arid conditions, the winter feed consists of dried hay and crop residues, including peanuts. Because the informal sector usually has a low-input/low-output system, the cheapest feeds are bought and no quality control is used (Manzana, 2007; Prozesky *et al*., 2004).

- **Physical hazards** are significant for F1 and F2 in regard to udder injuries due to the automatic milking process that can lead to mastitis. Physical hazards influencing milk quality, related to manure, urine, dust, hair and flies are present in farming systems F3, F4, F5, and F6. They can occur during the milking or are due to contamination of the milk in the bucket during or after milking procedure. The main physical hazards for the environment are due to:

- Runoff of dirty water and urine.
- Manure accumulation.
- Discarded milk.
- Effluents from value added processes such as manufacture of cheese and yoghurt.
- Trampling, urinating, defecating while drinking from rivers, streams and lakes.
- Carcasses of dead animals.

o **Chemical hazards** for the environment are represented by nitrogen, potassium and organic nutrients from manure or discarded milk. Carbon dioxide and methane emissions form the living cattle, discarded feeds and manure, can also pollute the environment. Runoff water can contain chemical residues such as stock remedies, antibiotics, detergents, disinfectants, parasiticides and other agricultural chemicals.

Veterinary drugs residues, detergents, disinfectants and agricultural chemicals are potential hazards mainly on farming systems F1, F2, F3 and F7 because they are regularly used for commercial animals. In systems F3, F4, F5, F6, the risk of agricultural chemicals and stock remedies is lower because they are low - input low - output systems and few are used (Manzana, 2006; Prozesky *et al.,* 2003).

4. 4. 4 Effects or consequences of the identified hazards

4.4.4.1. Consequences related to human health

The WHO lists the following consequences for humans exposed to milk and or water containing microbiological/ biological agents (as listed in Section 4.4.2)

<u>Table 4.15</u> Consequences of the hazards from traditional farming systems in SA and in Benin (F3, F4, F5 and F6).

Hazards	Consequences Water pollution and water depletion	Observation Likelihood / Magnitude of the hazard	
		Benin	SA
Biological Hazards	• Transboundary diseases, zoonoses, food borne diseases, water and food related illnesses.	+//3	+/- //1
	• Negative economic impact	+//3	+/3
Chemical hazards	• Reduction of biodiversity	+/2	+/3
	• Modification of biodiversity; alien species, algae	+/3	+/3
	• Antibiotic resistance.	+/-/1	+/-//2
	• Eutrophication of surface water and aquatic ecosystems.	+/3	+/3
	"Dead" zones in coastal areas.	+/-//1	+/-//2
	• Health problems due to nitrogen into groundwater, toxins (methemoglobinemia, poisoning, human cancers)		
Physical effects	• Negative effects on the replenishment of	+/3	+/-//1
	• Freshwater. Reduction of potable water		
	• Arising of BOD level on water quality due to total organic carbon	+/2	+/-//2
	• Modification of the texture of the soil which becomes compact and reduces the infiltration. Degradation of banks of watercourses, the floodplains dry and the water table become lower.	+/3	+/-//1
	• Sedimentation of the lakes and rivers	+/3	+/-//1

Table 4.16 Consequences of the hazards from commercial farming systems in South and Benin (F1, F2, and F7).

Hazards	Consequences Water pollution and water depletion	Observation Likehood/ Magnitude of the hazard	
		Benin(State farms)	SA
Biological Hazards	• Transboundary diseases, zoonosis, food borne diseases, water and food related illnesses. • Negative economic impact	-/1 -/1	-/1 -/1
Chemical hazards	• Reduction of biodiversity • Modification of biodiversity; alien species, algae • Antibiotic resistance. • Eutrophication of surface water and aquatic ecosystems. "Dead" zones in coastal areas. • Health problems due to nitrogen into groundwater, toxins (lethal methemoglobinemia, poisoning, human cancers)	+/-//1 +/-//1 +/-//1 -/1 -/1	+/3 +/3 +/-//3 +/3 +/-//3
Physical effects	• Negative effects on the replenishment of freshwater. Reduction of potable water. Padding of water points • Arising of BOD level on water quality due to total organic carbon • Modification of the texture of the soil which becomes compact and reduces the infiltration. • Degradation of banks of watercourses, the floodplains dry and the water table become lower. • Sedimentation of the lakes and rivers	- - - -	- +/3 +/3 -

-Likelihood of the hazards identified (Probability):

++: Highly certain (High)

+: Certain (medium)

+/-: More less (low)

-: Negligible

Magnitude:

0: Not important (Negligible)

1: Not very important (Mild)

2: Fairly important (moderate)

3: Very important (Severe)

4.5 Identification of the Control points (CPs) and the CCPs (HACCP: Step 7/ Principle 2)

4. 5. 1 Decision tree for Critical control points

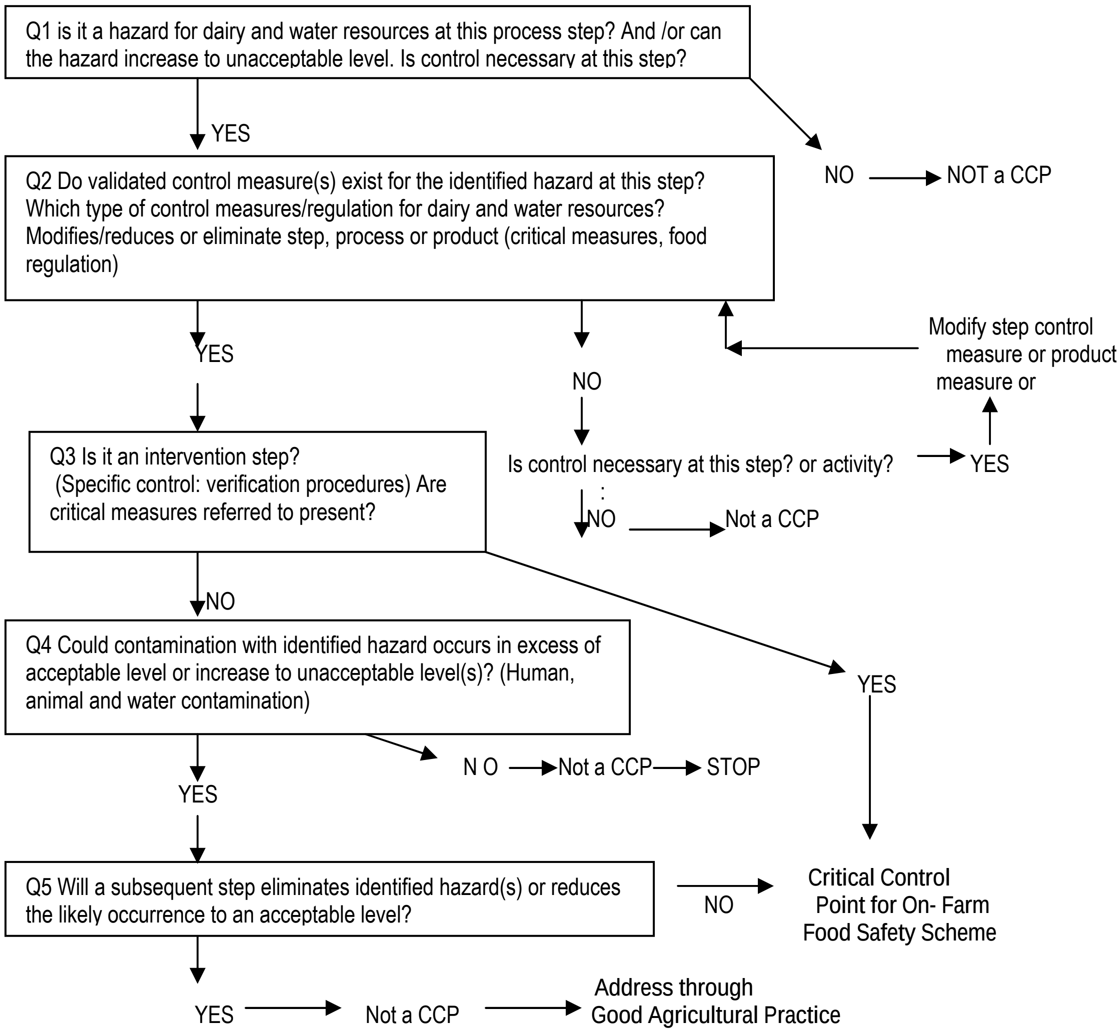


Figure 4.9: Modified Critical control points decision tree for dairy pollution of water resources (Adapted from the template of Horchner *et al*., 2006).

The decision tree shown in Figure 4.9 above determines the steps which could be considered as critical control points. It defines where the hazards will be controlled. It is adapted from the principles included in the Codex HACCP guidelines for milk and dairy products (CAC, 2004). Thus, animal health, milking hygiene during the process of raw milk harvesting and water quality (water supply) are enlighten during this investigation. The CCPs involve both dairy production and safety issues around water resources at the farm level.

The decision tree concerns both food safety and environmental issues, in order to protect the health of the consumer; the fundamental principles of HACCP are considered as well as current environmental norms. In this decision tree, water is a control point at each step of the production.

Water use, water pollution and water resources management in dairy farms are important to decisions taken. Question 3 related to the intervention step, has been included as in was done in the Horchner template: "An *intervention step is one which has been included to control and identified. It does not refer to a preventive measure applied at a process step undertaken for another purpose"* (Horchner, 2006).

Although clear for commercial systems (F1, F2), the treatment of questions 2 and 4 is complex for F3, F4, F5, F6 and F7 because traditional African management is used on these farms and most of the literature on HACCP is applied to commercial farms in Europe and America. In the case of system F7, GAP norms are respected, but international norms for dairy management are not strictly implemented in farming systems F3, F4, F5, and F6 as traditional practices are still in force. Validated measures are mainly international norms and standards which need to be adapted to each situation. Data related to previous results of analysis on dairy farms are also scarce and frequently concern non - specific analysis of water pollution of water resources. Answers to question 5 in the CCP decision tree regarding subsequent steps to control the hazard is complex for farming systems F3, F4, F5, F6 because none of them are committed to a formal commercial purpose. Horchner *et al.,* (2006), remarked that: "*subsequent steps as a means of controlling hazards is always difficult for enterprises early in the food chain, chiefly because the product is not yet in the form that will be consumed*." This is very applicable to the case of raw milk production where hazards at the primary production phase on farm, may only have an impact at the secondary level of value-added in the dairy product factory, for instance yoghurt or cheese.

Table 4.17: Examples of decisions taken in a derivation of critical control points (CCP) and control points (CP) for on-farm food safety (Husbandry practices)

Process steps	Activities associated with this step	Hazard	Water use	Source of pollution	Q1	Q2	Q3	Q4	Q5	CCP or CP
4.Husbandry practices (in connection with dairy production)	-Intensive/ extensive dairy system - Mating - breeding and reproduction, culling - program/pregnancy testing	B, Ph (injuries, udder and teats' diseases, production system diseases			N N N N	Y Y Y N	N Y N Y	Y Y N N	- - - -	Not a CCP As above As above As above
	-Weaning -Marking -Washing and cleaning of equipments, housing and milking area.	B, Ch, Ph	+	Staphyllococcus, Disinfectants residues	N N Y	Y N Y	Y Y Y	Y ? N Y	- - -	As above As above GDP
	- Milking hygiene (udder preparation, equipment, milkers)	B			Y	Y	Y	Y	-	CCP

Table 4.18: Examples of decisions taken in a derivation of critical control points CCPs) and control points (CPs) for on-farm food safety (Pasture and cropping Feedstuffs and additives)

Process steps	Activities associated with this step	Hazard	Water use	Source of pollution	Q1	Q2	Q3	Q4	Q5	CCP or CP
5. Pasture and cropping	-Movements on farm/between herds, camps or farms	B	-	A	Y	Y	N	Y	Y	GAP
	-Manure disposal -Management of pasture and /or crop quality -Application of pasture and /or crop chemicals	B, Ch Ch Ch	- - -	A P P	Y N Y	Y Y Y	Y N N	Y - Y	N - Y	CCP For F1, F2, F3, F6, F7 GAP
	-Disposal of chemicals	Ch	-	P	Y	Y	Y	Y	N	CCP for F1, F2, F7
6. Feedstuffs and additives	-Management of alternative feed sources -Feed disposal	Economic issues		P P	Y Y	N Y	Y Y	- Y	- Y	GAP CCP for F1, F2, F7

KEY	
Q1: Was there a hazard at this step?	Q4: Could contamination with the identified hazard occur?
Q2 Do validated control measure(s) exist for the identified hazard at this step?	Q5: Are hazards reduced or eliminated?
Q3: Is it an intervention step	Decision taken: CCP or CP
	Significance: Q1 (Severity), Q2 (likelihood), Q3 (significance)

<u>Table 4.19:</u> Examples of decisions taken in a derivation of critical control points (CCPs) and control points (CPs) for on-farm food safety (water supply)

Process steps	Activities associated with this step	Hazard	Water use	Source of pollution	Q1	Q2	Q3	Q4	Q5	CCP or CP
7. Water supply Drinking, cooling and washing of animals, service	-Water source -Storage -Distribution system	B, Ch, Ph urine)	- -	A/P (Nitrogen and other.), Ph (taste and odour, trampling mud, pollution by manure.	Y Y Y	Y Y Y	Y Y Y	- - -	- _ _	CCP CCP CCP
	-Control of effluents - Wastewater and other liquid wastes management (endpoints)	Ch, Ph (leaking and other deficiencies in water pipes and taps)	-		Y Y	Y Y	N N	Y Y	Y Y	GAP GAP

KEY
Q1: Was there a hazard at this step?

Q2 Do validated control measure(s) exist for the identified hazard at this step?

Q3: Is it an intervention step

Q4: Could contamination with the identified hazard occurs?

Q5: Are hazards reduced or eliminated?

Decision taken: CCP or CP

Significance: Q1 (Severity), Q2 (likelihood), Q3 (significance)

<u>Table 4.20</u>: Examples of decision taken in a derivation of critical control points (CCPs) and control points (CPs) for on-farm food safety (animal treatment and care)

Process steps	Activities associated with this step	Hazard	Water use	Source of pollution	Q1	Q2	Q3	Q4	Q5	CCP or CP
8. Animal treatment and care (welfare)	-Animal health program: dipping, injecting, vaccinating	Ch	+	P	Y	Y	N	-	-	GAP
	-Carcass disposal -Control introduction of animals of known health status onto the farm -Dairy production enhancers	B: indicator bacteria and microorganisms of public health concern Ph		A P	Y Y Y N	Y for F1, F2, only Y	Y Y N Y	- - N Y	- - -	CCP CCP Not a CCP
	-Agricultural and veterinary prescribed drugs and chemicals -Security of biodiversity -Diseases and parasites controls	-Ch: chemicals and drugs residues Ph, Ch B for *M bovis*	+	P A A	Y Y Y	Y Y Y	Y N N	 N Y	- - Y -	CCP GAP Not a CCP GAP
	-Secure boundaries onto the farm -Clean equipment -Isolation of sick animals	*, Brucella & Anthrax* B(Zoonosis), Ph injuries		A P A	Y Y Y	Y Y Y	Y N Y	- Y -	- - -	CCP GDP CCP
	-Purchase, reception, storage and preparation of chemicals -Approval for the use/of label use -Appropriate training of people -Competent and registered professionals - Identification and traceability of treated animals	Ch B, Ph B, Ch As above B			Y Y Y Y Y	Y Y N Y Y	N N N N N	- N N N N	- - -	Not a CCP Not a CCP Not a CCP Not a CCP Not s CCP

KEY
Q1: Was there a hazard at this step?
Q2 Do validated control measure(s) exist for the identified hazard at this step?
Q3: Is it an intervention step
Q4: Could contamination with the identified hazard occur?
Q5: Are hazards reduced or eliminated?
Decision taken: CCP or CP
Significance: Q1 (Severity), Q2 (likelihood), Q3 (significance)

Table 4. 21: Examples of decisions taken in a derivation of critical control points (CCPs) and control points (CPs) for on-farm food safety (transport of milk; livestock dispatch)

Process steps	Activities associated with this step	Hazard	Water use	Source of pollution	Q1	Q2	Q3	Q4	Q5	CCP or CP
9.Preparation for transport of milk and dairy products	-Cooling of milk in tanks (time, cleanness of milk storage area, equipment	B, Ch	+	P	Y	N		N	-	GDP
	-Safe access for bulk milk collection				Y	N	N	Y	-	GDP
10. Livestock dispatch	-Culling of old or sick animals	Economic issues			N	-	-	-	-	Not a CCP
	-Calves sale after late weaning	As above			N	-	-	-	-	Not a CCP
	-Calves sale after early weaning	As above			N	-	-	-	-	Not a CCP
	-Old or sick animals sale	As above			N	-	-	-	-	Not a CCP
	-bulls, heifers, cows stay in the herd									

KEY

Q1: Was there a hazard at this step?

Q2 Do validated control measure(s) exist for the identified hazard at this step?

Q3: Is it an intervention step

Q4: Could contamination with the identified hazard occur?

Q5: Are hazards reduced or eliminated?

Decision taken: CCP or CP

Significance: Q1 (Severity), Q2 (likelihood), Q3 (significance)

Table 4.22: Examples of decisions taken in a derivation of critical control points (CCPs) and control points (CPs) for on-farm food safety (Environmental care)

Process steps	Activities associated with this step	Hazard	Q1	Q2	Q3	Q4	Q5	CCP or CP
11.Environ-mental care	-Storage of wastes: Inspection for signs of leaks, failures; plastic silage wraps.	B, Ph, Ch	Y	Y	Y	Y	N	CCP
	-Management of pastures to avoid effluents runoff by spreading farm manures in accordance with local conditions (conditions and soil types, buffer zones, identification of areas on-farm with high risk of pollution, statutory rates of application of manure spreading, waste management plan).	B, Ch	Y	Y	N	Y	Y	GDP
	-Contention of dairy runoff on-farm (locate, store and adequate use of storage facilities for polluting substances)	B, Ch and Ph	Y	Y	Y			CCP
	-Use chemicals appropriately to avoid combination of the local environment (ensure safe and secure storage away from the dairy; registered chemicals; safe disposal of expired or defective chemicals	Ch	Y	Y	Y	-	-	CCP
	-Ensure overall appearance of the dairying operations appropriate for a facility in which high-quality food is harvested (cleanness of farm surrounding, sheds; access roads free of effluents)	Economic issues	N	Y	N	-	-	Not a CCP

KEY

Q1: Was there a hazard at this step?

Q2 Do validated control measure(s) exist for the identified hazard at this step?

Q3: Is it an intervention step

Q4: Could contamination with the identified hazard occurs?

Q5: Are hazards reduced or eliminated?

Decision taken: CCP or CP

Significance: Q1 (Severity), Q2 (likelihood), Q3 (significance)

4.5. 2 Identified CCPs

The critical control points are distributed between the different types of farms. The identified CCPs (table 4. 16 to 4.21) are listed below:

CCP1: Husbandry (dairy practices) - Milking hygiene (Table 4.17)
CCP2: Pasture and cropping - manure disposal (Table 4. 18)
CCP3: Pasture and cropping - Disposal of chemicals (Table 4. 18)
CCP4: Feedstuffs and additives - Disposal of unsuitable or corrupted feed and additives (Table 4.18)
CCP5: Water supply - water sources, water storage and distribution systems (Table 4.19)
CCP6: Animal treatment and health care - carcass disposal (Table 4. 20)
CCP7: Animal treatment and health care - introduction of animal with known health status (Table 4.20)
CCP8: Animal treatment and health care - use of chemicals and veterinary prescribed drugs (Table 4.20)
CCP9: Animal treatment and health care - Security of boundaries around the farm and access to farm (Table 4. 20)
CCP 10: Animal treatment and health care - Isolation of sick animals (Table 4.20)
CCP11: Environmental care – containment of dairy runoff on – farm (Table 4. 22)
CCP12: Environmental care – appropriate use of chemicals (Table 4.22)

CCP 3, 8 and 12 can be considered and managed together. However uncertainties (?) can be noticed in the likelihood for occurrence of the hazards related to water sources and dairy runoff on-farm, in the case of F3, F4, F5, and F6.

4.6 Dealing with other steps in the sequence of HACCP (steps 8, 9, 10, 11 and 12)

CPs and CCPs regarding water pollution in dairy at the farm level are related to activities like husbandry practices, pasture and crops, feedstuffs and additives, water supply, animal treatment and health care and environmental care. Mitigation of hazards, particularly environmental hazards resulting in water pollution, are also governed by regulatory aspects and this will be described in a subsequent section.

Steps 2, 3, 4, 5, 6, 7could be considered as risk assessment. Step 11 is relevant to risk mitigation/management and step 12 is related to risk communication.

Table 4.23: HACCP: identifying critical control points and application of remaining HACCP principles

Process step and activities	CCP No	Hazard	Control measure	Critical limit	Monitoring procedures	Corrective action	Verification methods
4.Husbandry (dairy practices) Milking hygiene	CCP1	Biological	Control of cleaning of , udder and equipment				
Process step and activities	CCP No	Hazard	Control measure	Critical limit	Monitoring procedures	Corrective action	Verification methods
5. Pasture and cropping	CCP2	Biological: E coli E 157and coliforms(Manure)	Prevention: Manure disposal for F1, F2, F7 Control of pasture areas (Buffer areas near water sources for F3, F4, F5, F6	In raw milk: In water: NIL toleran ce	Laboratory control of samples of manure and fecal material	Health care (antibiotic, antiparasites)	Regular water samples laboratory tests antibiograms
	CCP3	Chemical: Nitrogen and other nutrients and other contaminants Chemical for pasture and crops	As above. Surveillance of water pipes		Laboratory controls, BOD, COD	Management of pasture. Management of manure	
7. Water supply Drinking, cooling and washing of animals, service	CCP4	-Biological: FMD and other faecal germs, Corynebacteriu m -Chemical: Detergents, effluents -Ph: mud, manure, urine, Faecal contamination	Control of water quality/ contamination Control of water sources Control of water distribution system Control of water storage -Control of effluents -Control of waste water and liquid wastes		Laboratory controls of water supply Control of effluents/ management of waste water	-Purification of water supply - Maintenance of Water storage system and water distribution system - Management and treatment of wastewater (recycling)	Regular checking of water sources quality surrounding the farm -Together with Physicians, information on water borne and milk borne diseases Control of biodiversity in water sources (alien species, algae, other flora and fauna

<u>Table 4.23 continued</u>: HACCP identifying critical control points and application of remaining HACCP principles

Process step and activities	CCP No	Hazard	Control measure	Critical limit	Monitoring procedures	Corrective action	Verification methods
8. Animal treatment and care (welfare) -Carcass and raw milk form sick animals disposal	CCP5	Biological and chemical	Separation of health animals and sick animals, Destruction (incineration, use of chemical as NaOH) Quarantine, control of various certificates Control of the prescriptions, the documents delivered and	- -	Health program, control sheets	Control measure far from water sources	Regular checking of records sheets-
-Control introduction of animals of known health status onto the farm	CCP6	Biological (zoonosis)		On the use directions	Records sheets -	Only animals of known status	As above
-Agricultural and veterinary prescribed drugs and chemicals	CCP7 CCP8	Chemical (drugs residues} the use of the drugs Biological, chemical and physical		-	-	Prescription only by the Vet	Regular farm visits
11.Environmental care -Storage of wastes. -Contention of dairy runoff on-farm -Use chemicals appropriately to avoid combination of the local environment	CCP8 CCP11	Biological, chemical and physical Chemical Inspection of signs of leaks, failures Location, storage and adequate use of storage facilities for polluting substances Ensure safe and secure storage away from the dairy; registered chemicals; safe disposal of expired or defective chemicals		- -	- -	Rectify the cause of leakage - -	Regular inspection (security audits) Laboratory tests of water sources surrounding the farm

CHAPTER 5

DISCUSSION: LEGISLATION AS RISK MITIGATION IN SA AND BENIN

(APPLICATION TO CCPS)

5.1 Introduction

In Chapter 4, the CCPs connected with water pollution in dairy farming systems were identified after analysis of data. In this Chapter, the legislation and its use as a control factor to mitigate the effects of the identified hazards in each farming system will be discussed.

The mitigation of these hazards can only be achieved by following the HACCP system. This means that CCP's should have been identified (See Section 2. 5. 2 of Chapter 2, Literature Review). These CCPs will be discussed in Chapter 5 and the role of mitigation through legislation considered.

5.2 Discussion of the identified critical points (CPs) and critical control points (CCPs) and their mitigation through legislation

In line with the logical sequence of the HACCP based approach, the focus is to identify CCPs in the production of milk, that have a potential impact on water purity and safety. In the sections below, we will consider the existing legislation and how it mitigates the hazards identified under each separate CCP. HACCP is a flexible system. Thus, CPs and CCPs will be discussed depending on the type of farming system and the related mitigation. Some CCPs can appear as CPs according to the specificities noticed in each type of farming system. Prerequisites and preventives control measures covered by legislation are fundamental for the mitigation of these CCPs.

As listed in Chapter 4, Section 4.5, eleven CCPs have been identified for the seven farming systems altogether. They are:

- CCP1: Husbandry (dairy practices for housing and milking parlour. cleaning and washing , milking routine)

- CCP2: Pasture, crop residues and also zero grazing (barns) - manure disposal[1]
- CCP3: Pasture and cropping - disposal of chemicals[2]
- CCP4: Feedstuffs and additives - disposal of unsuitable or corrupted feed and additives[3]
- CCP5: Water supply - water sources, water storage and distribution systems[4]
- CCP6: Animal treatment and health care - carcass disposal [5]
- CCP7: Animal treatment and health care - introduction of animal with known health status
- CCP8: Animal treatment and health care - use of stock remedies[6]and veterinary prescribed drugs[7]
- CCP9: Animal treatment and health care - security of boundaries around the farm and access to farm
- CCP 10: Animal treatment and health care - isolation of sick animals[8]
- CCP11: Environmental care - containment of dairy runoff on - farm
- CCP12: Environmental care - chemical outputs

Tables 5.3, 5.4 and 5.5 are a summary of the mitigation of these CCPs.

5. 2. 1 Husbandry practices specific to dairy production: CCP 1

In traditional systems, milking hygiene is recognized as a CCP related to husbandry practices in dairy production. Deficiencies of the hygiene of udder, teats, equipment and milkers, can lead to biological and physical hazards. Zoonosis dues to milk borne diseases such as Tuberculosis (*M. bovis)*, Brucellosis (*B. abortus and B. melitensis,* although the latter is more commonly found in goats than cows*), and Cryptosporidium are* the most important public health consequences reported. *E coli 0157* (in cows' faeces), and *Staphyllococcus aureus* (in mastitic milk*),* are also seen as emerging zoonoses, that may be of importance in the dairy sector (WHO, 2007). Diseases due to *Campylobacter spp, Listeria ssp, Salmonella spp* may also result from polluted water *(*FAO, 2002; OIE, 2007(b); Michel & McCrindle, 2004(d); Schlundt *et al.*, 2004; Steinfeld *et al*., 2006)*.* Although the sources of water pollution involving these hazards are indirect, or not completely clarified, they should not be totally ignored in traditional farming systems where there are optimal conditions of water contamination and the viability of these microbiological organisms in the environment is important (Hempen *et al.*, 2004;WHO, 2000(a)).

[1] Manure disposal in intensive systems –TMR (zero grazing systems where manure is washed out)
[2] Note that registration of safe agricultural chemicals are a prerequisite in SA due to Act 36 of 1947
[3] Note that registration of safe feedstuffs are a prerequisite in SA due to Act 36 of 1947
[4] Note that potable water for dairies in SA is a prerequisite due to the Health Act 63 of 1977 reviewed, Health Act 61 of 2003
[5] Note that safe carcass disposal is a prerequisite in SA due to the Animal Diseases Act (Act no 35 of 1984) Regulations V111
[6] Note that safe use of registered stock remedies and parasiticides in SA is a prerequisite due to Act 36 of 1947
[7] Note that safe use of registered prescription drugs is a prerequisite in SA due to Act 101of 1965
[8] Note that quarantine facilities are a prerequisite for registration of dairies in SA due to Act 35 of 1984 and the Health Act 61 of 2003.

In commercial intensive systems, water use and water supply at this process step and the related activities is important. The recorded hazards can be a threat through waste water. The CPs concern mainly husbandry practices in milking parlour on one hand and husbandry in zero grazing and TMR intensive systems on the other. The hazards are listed below:

- In the milking parlour, run off and effluents are composed of :
    - detergents used to clean surfaces and equipment,
    - disinfectants used to sterilise surfaces and equipment,
    - faeces from cows
    - urine from cows,
    - spilled milk,
    - washing water of up to 40 litres/ cows/ day to clean udders, floors etc.

- In zero-grazing and TMR intensive systems water purity is threatened by effluents containing:
    - feed residues
    - bedding (straw or sand)
    - faeces (very high due to high production and high population density in barn)
    - water use; up to 10, 100 litres run through flood cleaning about 3- 4 times a day for +/- 500 cows.
    - The magnitude of hazard is very high.

5. 2.1.1 Specific International legislation as mitigation: SA and Benin

SA and Benin are under international legislations related to milking hygiene as follows:

- For general conditions and prerequisites for milk safety: The "*EU Directives of Code of Hygiene Practices*" (EEC, 1993), the general requirements for food hygiene" (CAC, 1997) and *the "Code of hygienic practice for milk and milk products CAC/RCP 7-2004"* (CAC, 2004).
- For the level of detergents/ disinfectants in milk: The "*Codex Alimentarius Standards, recommendations and guidelines for food safety"(CAC,* 1999; CAC, 2001;CAC, 2004).
- Specific standards are described in the Codex "Official Standards list" (CAC, 2007(b)).

The legislation relating to milking hygiene is mainly applicable to farming systems where automatic milking is used and marketing through formal channels (F1, F2). The general legislations as laid down by Codex and the OIE also apply to manual milking (F3, F4, F5, F6 and F7); however it is not always practical to implement them where the dairy farming and marketing systems are informal and unregulated (F3, F4, F5 and F6). The FAO/IDF "Guide to Good Dairy Farming Practice" as well as the FAO Document "Hygienic Milk Handling and Processing" designed for small-scale farmers in Kenya, give some good guidelines for Milk Hygiene and Quality Control (FAO/IDF, 2004; FAO, 2007(a)).

5. 2. 1. 2 National legislation as mitigation

CCP1 is strongly mitigated by a complete and regularly reviewed national legislation and is applicable for F1 and F2. It is mentioned by institutions such as the DSA.

Although F7 is committed to an improvement of dairy production, there is a deficiency to national legislation which is not specifically related to milking hygiene as developed into Chapter 2.

CCP1 is not mitigated by national legislation in F3 and F4 which are located in SA, similarly to F5, F6, and F7 in Benin are not well mitigated by current legislation.

This is discussed in more detail under each country, below:

- In SA, the main legislation related to milking hygiene is handled by The Health Act and its regulations, administered by the Department of Health (Act 63 of 1977). Government notice "R 1255 of 27 June 1986" on the regulations relating to milking sheds and the transport of milk are important for milking hygiene. The regulations describe the duties of the veterinarian for the control of problems associated with milk production. These regulations are sufficiently detailed and applicable to commercial dairy farms F1 and F2; they are well monitored by the DSA specifically through the control of disinfectants which emphasizes to the use of registered disinfectants and detergents (Act 36 of 1947 (as amended) for farm feeds, fertilizers, agricultural chemicals and stock remedies)[9] (NDA, 2007). Husbandry practices connected with cleaning and washing are covered by the prerequisites included in this Act; they should be considered as GDP rather than a CCP. The implementation of GDP is well regulated in commercial dairy farms F1 and F2, and more recently biodegradable products are preferred for registration.

[9] *www.nda.agric.za/docs/**act36**/eng.htm*

However, this legislation is not specifically aimed at the avoidance of water pollution by dairy production. Thus, disposal of effluents and manure as advocated by the FAO/IDF Guide to Good Dairy Farming Practice is not yet covered by specific legislation although the Hazardous Substances Act (Act No 15 of 1973) can be applied (DOH, 1973; DOH, 2005). The disposal of milk containing antibiotic residues and milk from mastitic cows, is not well implemented or regulated.

Legislation is not yet well implemented in F3 and F4. Deficiencies in GDP and GHP, a lack of awareness by the farmers, as well as some deficiencies in the applicability and the control of national, provincial and local (municipal) legislation in the informal (unregulated) market explains the situation (Martinus, 2004).

For all the farms in SA, control points related to zoonosis are well mitigated by legislation for Brucellosis and Tuberculosis in the Health Act 63 of 1977and; Regulations pertaining to Animal Diseases (Act 35 of 1984) (NDA, 2007; DOH, 2005). However the legislation for control of other milk-related zoonosis in dairy effluents and runoff water, which are neither notifiable nor controlled has not yet been promulgated.

- In Benin, the Food Control Act No 84 -009 of 1984; The Code of Public Hygiene (Public Health Code No 87-15 of 1987) administrated by the Department of Health; and Ordinance No 72-31 of 27 September 1972 (relating to the regulation of Sanitary Policing and Inspection of Food of Animal Origin) administered by the Department of Agriculture, Livestock and Fisheries (in charge of livestock); form the basis of legislation for milk hygiene in Benin.

  However - legislation applicable at–farm-level is outdated, not yet adopted or non-existent; thus implementation is not yet possible. For example the National Commission of Codex Alimentarius created in 1985 for application of the Food Control Act, is supposed to be a multidisciplinary institution in charge of the organization of all regulation of food control in Benin. According to this law, all the Departments concerned about food quality should be represented. This basic law is not currently applicable because the names as well as the organization of the Departments involved in this commission have been modified. In the meanwhile, some other organizations have been created, such as the CEBENOR (See Chapter 2).

The only permanent point in control is the fact that state veterinarians are in charge of the control and monitoring of raw milk hygiene at the farm level. Farm chemicals, stock remedies and veterinary drugs are registered, and veterinarians use only registered products. Unfortunately, unregistered products are available on the informal market.

5. 2. 2 Pasture and cropping and feedstuffs and additives: CCP2, CCP3 and CCP4

CCP2 is related to manure disposal and CCP3 to disposal of chemicals from pasture and cropping. CCP4 is connected with the disposal of unsuitable or corrupted feed and additives. This is discussed in more detail for each country, below:

- In SA, the basic laws which can be considered to refer to these CCPS are the Conservation of Agricultural Resources Act of 1983, the Hazardous Substances Act No.15 of 1973 amended No 53 of 1992, the Environmental Conservation Act of 1998 (part 1, 3, 4, 5 6), the National Environmental Management Act of 1997 and EIA regulations. The Foodstuffs, Cosmetics and Disinfectants Act 54 of 1972 is currently under review for milk and derived products. (Glazewski,2005; NDA,2007; NDOH,2005). Although these regulations are not specific to disposal on dairy farms, some international legislation is applicable but only at certain level. These are:

    - Agenda 21: the Action plan has been adopted in 1992.
    - The Convention on Biodiversity.
    - The Agricultural Sector Plan adopted in 2001.
    - The GMO Act 15 of 1997 implemented in 1999.
    - SA is signatory of the SPS Agreement and Sanitary and Phytosanitary Measures of the WTO which develops Governments' measures for the protection of human or animal or plant life, health and safety.

The EU regulations on one hand and the USA regulations on the other, have established some rules related to the effect of trade on the environment. These rules are supposed to meet the requirements of trade policies (GAP, GHP, GMP and HACCP). Restrictions on trade in GM production, or products from biotechnological processes have been recently developed for the export of dairy products. Thus, rules on labeling and traceability for GM products and environmental biotechnology rules have been established by the EU (IDFA, 2004)[10].

F1 and F2 are mostly concerned with CCP 2, CCP3 and CCP4 because the population density of cattle is very important. Crop chemicals are also used on large surfaces for the production of artificial pastures. Feeds and feed additives are used in several commercial farms, however, only registered agricultural chemicals and stock remedies can be used by commercial farms in SA, in terms of Act 36 of 1947(NDA, 2007). Manure can pose a serious threat to surface-water, ground-water, and water sources close by to a given farm, through soil and water runoff. Specific national regulations regarding manure disposal and chemical disposal on dairy farms are partly covered by the Health Act, the regulations pertaining to the Animal Diseases Act of 1984 (NDA, 2007), GAP and GDP. These are, however, not always well-implemented in F1 and F2.

Specific regulations regarding management of manure and chemicals and other parameters in regard to the distance between the farms and the water source and the maximum limits of quantities of manure should be specified. Critical limits are specified on labels of phytosanitary products and other agricultural chemicals used for artificial pastures.

F3, F4 do not always adhere to legislation at this stage of their development.

- Benin is under the same international legislation, policies and treaties as SA. In Benin the SPS Agreement exists for some hazardous substances and fertilizers. It aims mainly at crops for human consumption, but not artificial pastures, which are mainly experimental in Benin (F7). Feed and additives are represented by salt, limestone and small quantities of concentrated food. Legislation exists only for registration of imported feedstuffs and feed additives in Benin (CODEX/SPS/WTO risk assessment is applied to imports). Decision A/DEC.5/10/98 (Principles of the Regulation of Inter-States Transhumance in the Member-States of CEDEAO/ECOWAS of 31 October 1998), concerns the preservation of natural pastures and grazing in the Member States of ECOWAS (MAEP, 2004).

  Some rules related to the mitigation of CCP2, CCP3 and CCP4 can be found in the Frame-Act on Environment (No 98- 030 of 12 February 1999); the Law regulating use of communal pastures, the herding of animals and transhumance (No 87- 013 of 21 September 1987) as well as the

[10] www.idfa.org

Regulations for the Organization of Transhumance (No 039/MISAT/MDR/DCAB of 31 March1994). The Land Code, which was amended and validated by all the stakeholders in 2000, has been adopted, but has not yet been promulgated by the Parliament (DE, 2004; MAEP, 2004; MEHU, 2007).

The above legislation does not give enough explanation about procedures for the management and disposal of manure, discarded food or chemical wastes. Thus CCP2 and CCP3 are not mitigated in F5 or F6 in Benin, due to lack of locally relevant legislation. However, based on international guidelines, GDP and GAP are implemented in F7 in Benin.

F5, F6 and F7 do not need mitigation for CCP 4 by legislation at this stage of their development, because the amount of feed and additives introduced in these farming systems is very low.

5. 2. 3 Water supply: CCP 5

CCP 5 concerns water sources, water storage and water distribution systems.
International legislation has been published by several international organizations and many agreements have been signed by both countries (see paragraph 4 of Chapter 2).

- In SA, protection of water resources is strongly regulated in a strategic and regularly updated framework administrated only by DWAF (DWAF, 2006). The existing legislation on water supply includes:

    - The National Water Policy, 1997
    - The National Water Act 36/1998
    - The Water Services Act 108/1997
    - The Free Basic Water (FBW) Policy officially launched in 2001
    - The strategic Framework for Water Services (SFWS), 2003
    - The National Water Resource Strategy, 2004 and
    - The National pricing strategy for water, 2002.

In addition to the above legislation, the quality of water used in milk production is legislated in Government Notices R1555 of 21 Nov 1997, the Regulations pertaining to the Foodstuffs, Cosmetics and Disinfectants Act (Act 54 of 1972) related to milk and dairy products and

Regulation R 1255of 27 June 1986, relating to milking sheds and the transport of milk, of the Health Act (Act 63 of 1977) (NDA, 2007; NDOH, 2005). Mitigation of CCP5 is then fully sustained by a logical framework of legislation on water. However constraints exist in the implementation of these laws at farm level.

CCP5 is well mitigated by up-to-date SA legislation on Water for F1, F2, F3, F4; but this legislation is not well implemented in F3 and F4. The deficiencies noticed in the implementation of the relevant legislation by F3 an F4 might be due to the lack of information, education and awareness of farmers in systems F3 and F4. It may also be related to the informal nature of their milk production activities and the fact that they frequently use borehole and surface water (Prozesky *et al*., 2003).

- In Benin, the quality of water supply related to dairy is notified in the Public Hygiene Code of 1987 and chiefly concerns the quality of water used to produce infant formulae that contain dairy products. Up until 2007, the new “Water Code” (see earlier) had not been enacted by the National Assembly. There is no legislation regulating the quality of water used for dairy production at farm level.

  In Benin, the “Table-water Norm” and the “Waste-water Norm”, which were established in 2001 to rectify the lack of legislation related to water quality, are the current legislation applied to water quality in Benin.

  Water supply issues are not mitigated by legislation in the F5, F6 and F7 farming systems located in Benin. These deficiencies explain the poor information, education and awareness in F5 and F6 farming systems. However the country is committed to the implementation of a logical framework for water resources management and protection. In F7, awareness does exist, but there is no effluent control in place.

5.2. 4 Animal treatments and health care: CCP6, CCP7, CCP8, CCP9 and CCP 10

The above CCPs should be considered in any animal health program. They are related to:

- CCP6: Carcass disposal
- CCP7: Introduction of animal with known health status

- CCP8: Use of chemicals and veterinary prescribed drugs
- CCP9: Security of boundaries around the farm and access to farm
- CCP10: Isolation of sick animals

International legislation is published by the OIE, which provides complete and updated guidelines, norms and standards. SA and Benin are both members of OIE. They are obliged to send annual and scientifically based Animal Health Status Reports to the OIE. These reports are based on regulated National Animal Health Programs. All the above legislation (as described in Chapter 2) should be sufficient for the mitigation of these CCPs. However many constraints can be observed in regard to implementation.

- In SA, animal health is well monitored and documented by the farmers, private veterinarians and state veterinarians in F1 and F2. In the case of F3 and F4, some deficiencies can be noticed in carcass disposal, (CCP6) monitoring of the animals (documentation CCP7) and the security of boundaries and access to the farms (CCP9). However national boundaries are relatively well controlled in SA. The relevant legislation related to animal health in SA are given in Chapter 2. In SA, the use of chemical and veterinary prescribed drugs is well mitigated by legislation in F1, F2, F3 and F4, as only registered drugs are sold. Policing of illegal stock remedies is well implemented. The only exception to this is the practice of using home-concoctions like old tractor oil or mixtures of household detergents and disinfectants. Unregistered traditional herbal remedies are also used in F3 and F4, but these pose no threat to the environment or water safety (Prozesky, *et al*., 2003).

- In Benin, the monitoring of animal health in all systems is in line with international norms set by the OIE and this is under the control of state veterinarians. The delivery and prescription of registered veterinary drugs and stock-remedies are well controlled by the National Department of Agriculture, Livestock and Fisheries, through the "Regulation of Veterinary Pharmaceuticals in Benin" (No 517/MAEP/D-CAB/SGM/DRH/DE/SA of 2004 and No117/ MAEP/D-CAB/SGM/DE/CSRH/SA of 2003) (NDALF, 2003;NDALF, 2004). There is no specified health program for dairy farms and treatment of ailments in dairy cows does not always conform to the current international norms and is often traditionally based, except in system F7 (MAEP/DE/ PDE III, 2004, MAEP/DE/PDE III 2005).

As in SA, traditional herbal remedies pose no threat to the environment. Of more concern is the unregulated use of unregistered antibiotics, livestock remedies and parasiticides, particularly in system F5. Due to the cost of such medications, the use is very low and it poses more of a risk to the person consuming animal products than to the environment. Official boundaries exist but transhumant herds frequently cross the frontiers illegally (not at legal crossing points, where a fee is due and veterinary control is effective). Transhumance, with mingling of herds and cattle of different owners over extensive areas, leads to a high prevalence of various livestock diseases in Benin (DE, 2003, 2004 & 2005).

Notifiable and transboundary animal diseases are controlled and monitored through a specific national epidemiology program (DE/PACE, 2004) but this program does not specifically cover dairy production. Although clinical cases of tuberculosis and abortions or hygromas due to brucellosis, are recognized and reported by state veterinarians, it is difficult to monitor prevalence in transhumant systems and testing is not done with regularity (MAEP, 2003).

Both *Mycobacterium* and *Brucella* spp., can remain viable in water for extensive periods, perhaps even months (Coetzer & Tustin, 2005). Excretions and secretions from infected animals may thus pollute surface water during drinking. The relevant tests for tuberculosis and brucellosis are not governed by specific legislation in Benin, but are conducted in line with OIE recommendations in the Terrestrial Animal Code on the OIE website[11] (OIE, 2007(b)). Private and state veterinarians are committed to the monitoring of animal health over the entire country.

The mitigation of CCP 6, CCP7, CCP8, CCP9 and CCP10 does not fall under a specific legislation, although parts may be covered by Animal Health legislation in Benin (See Chapter 2). In Benin, a major constraint to finalizing dairy legislation, which includes milk and water safety, is the lack of a laboratory that is dedicated to routine milk and water analysis specifically for the dairy producer. There are, however, general laboratories that fill this function at present.

5.2.5 Environmental care: CCP 11 and CCP 12

CCP11 and CCP12 are discussed in line with the criteria of environmental care advocated in the "Good Dairy Farming Practice".
CCP 11 is related to the containment of dairy runoff and effluents on the farm.

[11] http://www.oie.int., 2007

CCP 12 is related to the appropriate use of fertilizers, agricultural and veterinary chemical to avoid contamination of the local environment by unsafe residues.

International norms ISO, 14000 and ISO 22000 as well as international rules and legislation related to the protection of water resources have been established since the Rio de Janeiro Summit in 1992 (ISO, 2005;ISO, 2007(b)). The "*Clean Water Act* "(Copeland, 2002) has been internationally relevant to water protection through environmental care since 1970. The FAO/IDF Guide to Good Dairy Farming Practice describes the different activities and measures to be taken on a dairy farm for sustainable environmental care. Several points relevant to water protection are given in this guide, because water is an important issue on the dairy farm (FAO/IDF, 2004).

- In SA, legislation on run-off, water resources protection (rivers, dams, lakes) as well as those related to chemical residues in effluent, is essentially contained in the Free Basic Water (FBW) Policy (2001), the National Water Resource Strategy, 2004 and the National Pricing Strategy for Water (2002). The National Resource Strategy is the basis for the mitigation of CCP11. The National Pricing Strategy for Water aims to implement the principle of "polluter pays" and is then in line with the mitigation of CCP12. Added to this, EIA regulations and environmental audits are administered by the DEAT. Although CCP11 and CCP 12 are mitigated by national legislation in SA, there appear to be deficiencies in implementation of environmental legislation, in general. The Endangered Wildlife Trust[1] claims that polluted rivers are due to poor catchment management in SA, despite the legislation in place to protect water resources (EWT, 2007).

- In Benin, as mentioned previously, the "Water Code" is under review and will be soon amended. This improvement positively affects the setting up of basic legislation on water. A well organized framework and strategy for water resource protection will only be able to be regulated and implemented once this is in place. Although impact assessment and some audits have already been done, the existing legislation on Impact Assessment (2001), Environmental Audits (2001) and Environmental Cells (2002), as described in Chapter 2, will then easily be implemented. Currently, however, there are serious deficiencies in legislation related to water resources (Onibon, 2006).

Mitigation of the different CCPs in SA and in Benin is summarized in Tables 5.1, 5.2 and 5.3 below:

1 http://www.ewt.org.za, 2007.

Table 5.1: **Identified CCPs in SA and situation of mitigation by control measures**

Farming system	CCPs mitigated by control measures (GAP, GDP, GHP, GMP)	CCPs not mitigated
F1 Commercial large scale farming system	• CCPs 1 to CCP10	• CCP 11 - CCP 12?
F2 Commercial small scale dairy farming system	• As above	• As above
F3 Informal dairy farming system	• CCPs 2? 3? 4? 6, 8? 9?	• CCP 1, 5(water source), 7, 9?, 10?, 11 and 12
F4 Communal dairy farming system	• As above but CCP 8 and 9 are not mitigated	• CCP 1, 5 (water source), 7, 8, 9, 10, 11, 12

Table 5.2: **Identified CCPs in Benin and situation of mitigation by control measures**

Farming system	CCPs mitigated	CCPs not mitigated
F5 Transhumance	CCPs 2, 3, 4, 8	• CCPs 1, 5, 6, 7, 8, 9, 10, 11
F6 Sedentary system and Agro pastoral	As above CCPs 2, 3, 4, 5, 7, 8	As above CCPs 1, 6, 9,10,11, 12
F7 Private and state farms	CCPs 1 to 10	• CCPs 11 and 12

Table 5.3: **Identified CCPs according to farming system: mitigation by legislation**

Legislation	Number and date	CCPs mitigated	CCPs not mitigated	Observation
• The Foodstuffs, Cosmetics, and Disinfectants Act	Act 54 of 1972	CCPs 2, 3, 4 F1, F2	F3, F4	-
• Government notice on the regulation related to milk and dairy products	R 1555 of 21 Nov 1997	CCP 1 F1, F2	F3, F4	-
• Government Notice related to the Schedule of the regulations relating to the application of the Hazard Analysis and Critical Control Point System (HACCP)	No 908 of 27 June 2003	Although implementation has started in some farms, this is the only regulation.	HACCP is not implemented at farm level	Dairy issues on farm are not specified HACCP still in the procedure of implementation
• Government Notice Amendment to the Regulation relating milk and dairy products	No759 of 2 July 2004	CCP1: F1,F2 (specific to microbiological tests (E.coli and coliforms)	F3, F4	-
• The Agricultural Products Standards Act,1990	Act 119 of 1990 R2581	CCPs 2, 3, 4 F1, F2, F3, F4		-
• Government Notice on Dairy Products.	R1469 of 6 August 1994	Related to GDP		

Table 5.3 continued: Identified CCPs according to farming system: mitigation by legislation

Legislation	Number and date	CCPs mitigated	CCPs not mitigated	Observation
• The conservation of Agricultural Resources Act,1983.	1983	CCPs 2, 3, 4 Standardization		-
• Hazardous Substances Act, No. 15	No 15 of 1973 Amended No 53 of 1992	CCPs 2, 3, 4 For F1 and F2	For F3 and F4	-
• National Water Policy • National Water Act • The Free Basic Water (FBW) Policy • National Pricing Strategy for Raw Water • The National Water Resource Strategy	1997 36/1998 Launched in July 2001 Implementation began in 2002 September 2004.	CCP 5 for all farms CCP 5 for all farms CCP 5 for all farms CCP 5 for all farms CCP 5 for all farms		-
International and Regional Regulations (OIE, WHO, FAO)	Number and date	CCPs mitigated	CCPs not mitigated	Observation
• Environmental Conservation Act (part 1, 3, 4, 5, 6) • National Environmental Management Act • EIA regulations The Implementation Plan	Act 73 of 1989 Act 107 of 1998	CCP6. 7. 8, 9, 10	CCP11 and CCP12	Many Environmental regulations exist but not specifically for environmental care and chemical use on dairy farm

5.3 Summation

In farming systems F1 and F2 CCPs 1, 2, 3, 4, 5, 6, 7, 8, 10 are well mitigated by control measures on-farm and by legislation. The same CCPs are not mitigated by control measures in farming systems F3, F4. Legislation related to these control points exists, but the implementation is not well managed.

In system F7 the same CCPs are mitigated by on farm control measures but some deficiencies related to strict samples tests are noticed. Mitigation by legislation is not yet in place. CCP5 is well mitigated by strong legislation in SA, but the legislation is not always well implemented.

CCP 11 and CCP12 are not mitigated by legislation, although environmental legislation is in place in both countries, this legislation is not directly related to water pollution on dairy farms.

In SA sufficient legislation exist for the majority of the CCPs recorded, except for CCP11 and CCP12. However the implementation of this legislation needs to be improved because SA has a very large commercial farming sector with producers in all provinces.

In Benin the legislation is not sufficient to cover the CCPs. Although water pollution is not a short term risk according to the characteristics of existing farming systems as described in Chapter 4, this legislation should be updated, completed and adapted to the new strategy for improvement of dairy production in Benin.

Although the CCPs relevant to the respective legislation in each country have been determined during the present study, the management of these CCPs should include better characterization of the hazards and their effects or consequences, to decrease the potential risk to water. The mitigation of the CCPs should consider the specificity and the importance of the hazards in each type of farming system described, and deals with the reported uncertainties. Thus, mitigation should be planned and implemented according to the dairy production objectives in each country.

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

6.1 Overview

In the hypothesis, it was suggested that comparison of HACCP for all the production stages (from the farm to the factory) in the dairy industry in Benin and South Africa, coupled with an examination of existing legislation in both countries, would allow for better risk mitigation in regard to water pollution, through suggested changes to legislation, particularly in Benin.

It has been concluded that farming systems can be divided into two main groups considering the steps and related activities:

- Group 1 represented by F1 and F2 in South Africa and F7 in Benin: These three are commercial systems with high producing dairy cows. Most of the hazards are related to high stocking density, high levels of organic waste (urine, faeces, discarded milk) and high water throughput (resulting in contaminated effluents) from drinking, cleaning and manure removal.
- Group 2 represented by F3 and F4 in South Africa; F5 and F6 in Benin, are characterized by low-input, low-output, small-scale, informal and traditional dairy farming practices. The main source of pollution is direct contamination of water and soil during drinking and grazing activities.

It was also found, in general, that SA had more detailed legislation and better mitigation of water pollution by dairy production than Benin. There were two types of legislation common to both countries:

- Legislation relating to animal health including disease control, registration of pharmaceuticals, disinfectants, detergents, feed, fertilizers and farm chemicals

- Legislation regarding water use and maintaining water quality

- In addition, SA had specific legislation pertaining to registration of dairies, including structure of facilities and control of effluents.

International policies, treaties and legislation on animal health, GAP and water protection, were recognized in both countries, but not always well monitored or implemented. The legislation regarding dairy, particularly that applicable to effluents and management of manure and water resources in Benin, has not been fully adopted and requires some updating in line with international requirements. The SA legislation could possibly serve as a model, although it, also is not always completely successful in preventing water pollution by dairy. GAP and some legislation (for instance Act 36 of 1998, which deals with stock remedies and farm feeds in SA) results in prerequisites existing for some dairy inputs like stock remedies, purchased food, disinfectants and detergents. Potable water was a prerequisite for dairy production in both SA and Benin.

HACCP was applied to both countries and twelve CCP's identified for all farming systems together. All of these were to some extent mitigated through local or international policies in the formal dairy systems (F1, F2 and F7) in both Benin and SA. However, the informal and traditional systems were only observing certain of the legislated CCP's. The validated control measures (mitigation and management of each hazard at the identified CCPs) are the national and international norms and standards and regulations. These must be applied theoretically to all the CCP's that have been identified in Tables 4.17, 4.18, 4.19, 4.20, and 4. 22.

Awareness of GAP and implementation of regulations should be included as part of counter measures, to improve dairy farming systems in both countries. Critical limits can only be determined after detailed analyses in each country and depending on various parameters of the different dairy farming systems recorded in this study. The determination of the critical limits should be considered as a long-term result.

As legislation changes frequently, or becomes outdated, modification should be an ongoing activity to be in line with the control measures for preventing contamination of water by dairy products. The mitigation of the CCPs linked to current legislation is complex, because it is always difficult to find the most recent regulation. International norms and regulations change frequently, some national regulations are regularly updated, some others are outdated and some of them are not in line with the policies and strategies. Not all the dairy stakeholders who could be involved in water pollution are aware of the prerequisites for dairy production, nor of environmental regulations. This situation is a constraint to the implementation of the regulations, the effectiveness of correctives actions, and further, the mitigation of water pollution due to dairy production and processing.

Risk assessment of water pollution by dairy at the farm level is complex. The complexity is related to the variability and the differences in the dairy practices. Although hazards have been identified in the different farming systems, their characteristics can be determined only through specific case studies as these characterizations are related to the likelihood, the severity and the significance of the hazards. These uncertainties are usually manageable in F1, F2, and F7, but not easily on F3, F4, F5, and F6, where GAP, GHP and GMP are not yet well implemented.

6.2 Suggested changes to legislation in South Africa

Animal health legislation in SA is very stringent and the level of livestock health prevents some forms of biological pollution by microbial pathogens (CCP6, CCP7, CCP8, CCP 9 and CCP 10). Registration of livestock remedies and chemicals is well implemented and there are almost no unregistered substances available for sale. This decreases the risk of chemical hazards (CCP8 and CCP 12).

In SA, dairy farming systems F1 and F2 have high levels of quality control, more as a result of the DSA, dairy processors and retailers, than state interventions. National legislation is in place, but even more important are the international policies for environmental safety in the dairy sector as mentioned in the publication "*Livestock's Long Shadow*" (Steinfeld *et al.,* 2006) and FAO/ IDF Guidelines for Good Dairy Farming Practice (FAO/ IDF, 2004). There are some serious deficiencies in the legislation for water safety, where no mention is made of effluents from dairy producers. In addition, there is a lack of detailed legislation (although it is mentioned in the Health Act 61 of 2003) for the control of effluents from dairy farms that could pollute water.

However, the informal system (F3, F4) is not well regulated in South Africa. F3 and F4 producers are selling milk illegally and could be prosecuted, however, the chief control measure is de-registration of dairy farmers (Health Act 61of 2003) and prevention of access to formal markets. According to Prozesky *et al.*, (2004) and Manzana, (2007), these farmers do not need to enter the formal marketing system as they have a ready informal market in rural areas at a better price than registered commercial dairy farmers. Thus the CCP for ensuring GAP is not being implemented. This is possibly because the Health Act is under the control of the National DoH and not the National DoA, thus sidelining veterinarians. Legislation could be changed, or the responsibilities allocated differently, to make sure that state veterinarians are more involved in all aspects of milk production, not just animal disease control.

To safeguard water, there should also be a great deal more collaboration between the DOA (including veterinary services), DEAT and DWAF. One of the main drawbacks is that veterinarians are not directly involved in the control and monitoring of water protection on dairy farms, although they are involved in animal health protection and epidemiology of diseases, many of which are water-borne. More interaction between the national institutions in charge of the regulatory measures and the creation of environmental multidisciplinary cells, as are found in Benin could be considered. The DOA, the DOH, the DEAT, the DWAF and the DTI should be represented in these cells.

Policies, strategies and regulatory measures relating to the dairy supply chain are based on a strong framework and well managed on commercial farms. Although some deficiencies have been noticed on communal and informal farms, the relevant legislation is widely implemented in South Africa. This situation has put the South African dairy supply chain at a good place in the world dairy market.

6.3 Suggested changes to legislation in Benin

In Benin, F7 adheres most closely to international norms for commercial dairy farming and milk safety. However, this may be more due to implementation of international standards, policies and treaties than local legislation. Part of the success of the state farms is due to inclusion of the veterinary profession in the management and quality control of these farms. The formalization of the suggestions for waste management (applicable to effluents and manure), made in the SA Report 455/01 could perhaps be considered in Benin and modified for dairy production as it is foreseen that this will become much more extensive in the near future (Strydom *et al.,* 2001).

As in SA, it is the informal sector where it is difficult to implement legislation. In the case of F5, the implementation is complicated by the fact that the transhumance brings these farmers under different legislation in different countries. This is particularly difficult in regard to control of trans-boundary animal diseases, some of which are serious biological hazards that survive and are transmitted to other animals and humans through water. Brucellosis and bovine tuberculosis are two good examples. The herds are large and even although the amount of urine and faeces produced by local breeds is small (due to lower ingestion of feed and water than is the case for the high producing intensively farmed breeds like Holsteins) , environmental damage and pollution of surface water sources such as rivers and lakes can be severe. It can include physical hazards such as mud, particulate matter from faeces and parts of carcasses or aborted material. Trampling disturbs the banks of these aquatic systems and they can become mud-holes. Fortunately, this is a low-input system and the farmers do not make much use of stock remedies and agricultural chemicals. However, due to the migration across borders, there is a probability that any that they do use would probably not be registered in Benin. There is a "Certificate of Transhumance" that should be used at borders; however herders often avoid the legal crossings in favour of illegal frontier crossings in order to avoid taxes, so control is difficult. Animal health, environmental and pharmaceutical legislation should be updated, preferably though consultation between all the countries of the ECOWAS/CEDEAO, to facilitate better control of transhumant dairy producers (ECOWAS, 2006).

In the case of F6, legislation is being updated and it would be possible for it to be implemented because the farmers are sedentary. In particular, it may be possible to register dairy producers in some way so as to facilitate better control of animal health. This would prevent the contamination of the environment by biological hazards due to zoonotic organisms. Mainly because of the low production, low stocking densities and the fact that the cattle mainly drink from troughs, F6 poses little danger to water sources through trampling or spread of biological hazards. Legislation pertaining to water use could be updated, perhaps using some of the Water Act (36 of 1998) of SA, as a model. In addition, regular monitoring of "table water" and water fed to dairy cows, for coliform organisms, would be advisable, so that if there is pollution through effluents and run-off into rivers, this could be controlled. Chemical hazards due to use of unregistered agricultural chemicals, could also be addressed through the existing legislation relating to Veterinary drugs and Pharmacy.

6.4 Reflection on Strategic decision-making.

Faye and Loiseau, (2002) asserted that:

"Worldwide, there are two alternative models for ensuring dairy product safety: in the USA, the focus is on regulatory control and sterilization, while in Europe, the focus is on managing quality and safety along the chain, from the cow to the consumer". The same authors advocated that "*the latter approach seem more appropriate in the developing country context where regulatory systems are weak and where contamination problems occur along the chain".* The above assertion has many justifications, particularly in Africa, depending on the dairy farming system and the control measures required (Droppers, 2006; OIE, 2007(b); Martinus, 2001).

In South Africa, the level of monitoring of water pollution requires that Larsen's "*Controlling strategy"* "could be used. This strategy is described as follows:

" *If the results of monitoring using the previous strategy showed that water quality standards have been violated, additional management tools are applied; effluent standards and wastewater discharge permits may be introduced in combination with enforcement and penalty procedures to handle violations has entered the proactive mode* (Larsen *et al*, 1997).

In Benin, *the "Criteria /standard only strategy"* should be used. This strategy is explained as follows:

"*The risk of environmental problems occurring justifies a more proactive approach to water pollution management, water quality criteria and standards may be formulated; monitoring of compliance with standards; still a passive mode of management in which no attempt are made to modify the system"* (Larsen *et al*, 1997).

6.5 Recommendations

Recommendations are given below for SA and Benin.

6.5.1 In South Africa:

The country has a long-standing commitment to systematic management of water resources; the Government of South Africa has developed a policy and a well-structured strategy of water resource management; institutions in charge of water resources are also well coordinated under DWAF. This strategy does not specifically include the effects of dairy production on water resources at farm level.

Recommendations include:

1) More interaction between the national institutions in charge of the regulatory measures: The creation of environmental multidisciplinary cells as in Benin can be considered. The DOA, the DOH, the DEA, the DWAF and the DTI should be represented in such cells.

2) The role of the veterinarian in the control of water pollution by dairy at farm level should be specifically included in the Health Act and reflected in legislation about water.

3) Preliminary training courses on HACCP and water protection issues should help community extension veterinarians to improve the awareness of waste water, manure and other potential contaminants disposal as well as potable water supply in systems F3 and F4.

4) Specific impact assessments on water resources surrounding different types of dairy farms or environmental audits should be conducted with veterinarians.

5) Improvement of the regulations related to protection of water resources at farm level for the dairy farm should include: water analysis along the entire chain of water supply .The results of these analyses should be required in commercial farming system (F1 and F2). Joint external audits by should be done by DOA, DEA and DWAF to control water pollution by communal and informal dairy systems (F3 and F4).

6) Amendments to Government Notice No 908 of 27 June 2003, (the Schedule of the regulations on the application of the HACCP systems for implementation and establishment of HACCP system at farm level), should be effected. This could be improved by regular surveys and appropriate training on HACCP at all levels.

7) Regular monitoring of BOD and COD as well as limits related to microbiological hazards other than *E.coli* (eg. *Mycobcterium tuberculosis, Brucellla abortus, Salmonella spp, Cryptosporidium spp and Staphylococcus aureus*).

8) Improvement of regular monitoring of effluents for hydrophilic pathogens like *Campylobacter spp* and *Corynebacterium spp* could also be conducted.

9) Specific control of effluents relating to chemical contaminants also should be implemented in farming systems F1 and F2.

10) The norms related to organic fertilization by manure could be established and implemented in dairy faming systems 1 and 2 because of the amount of manure produced. Report 455/01, 2001 includes an effluent action program with the following four steps. It is suggested these steps should be included in a legislation specific to the dairy industry:

- Waste prevention.

- Waste minimization.
- Waste recycling.
- Waste treatment.

11) Epidemiological surveys by the DOH should give information on potential or recorded milk-borne and water-borne diseases and zoonoses on dairy farms and in the surrounding areas.

As observed in report 455/01, (2001), such actions could facilitate the application of the principle of “Polluter pays” and the implementation of “the National Pricing Strategy for Water, 2002” to dairy producers who do not take sufficient precautions to prevent pollution of ground and surface water.

6.5.2 In Benin

Water policy and management strategy, as well as regulations, are still under review. However all the necessary steps have been taken for the adoption of a new “Water Code”.

Policies, strategies and regulations related to dairy products and water pollution are being amended. The methodic development of the dairy industry is at a early stage and changes in its development should be taken very progressively and carefully, considering the socio-cultural aspects of the dairy sector in Benin. The new Land Code will be adopted soon and should lead to the implementation of the rural aspects of land affairs.

However, some improvements are needed to prevent potential negative effects on water resources, resulting from new developments in dairy production in Benin. These improvements should be institutional and regulatory, and include the suggestions made by Onibon in 2006.

1) The Water Policy and Water Code should include livestock aspects

2) Laws and regulations related to milk, milk products and the dairy chain supply, should be completed with updated information.

3) The national institutions involved with livestock and dairy development, as well as water resources management, should be organized within a Global Strategic Framework, which allows them to work together: the model of SA water policy and strategy (DWAF, 2006) could be adapted

for Benin. These improvements would enable the Beninese authorities to avoid duplication and overlapping, which is a problem in the current legislation.

4) The National Commission of the Codex Alimentarius and the Environmental Cells, created in each Department in Benin should be updated and become more active.

5) Primary environmental impact assessments and/or external audits should be conducted in recognized dairy areas.

6) Cotton for commercial purpose and dairy farming are developed in the zones of *Borgou* and *Alibori*. Thus, the use of chemical fertilizers is important in these areas and control measures through legislation should be considered. Manure management and waste disposal, which has already started on the state farms, should be improved in order to develop sustainable, environmentally friendly, organic fertilization. This would reduce the risk of chemical hazards.

7) The settlement of new dairy farms should consider the location of watercourses and new dairy farms should be licenced.

8) Regular training and education on GAP, as proposed in the FAO Guide to Good Dairy Farming Practice (FAO/IDF, 2004) should be given to primary stakeholders in the dairy supply chain. Community extension veterinarians would be the primary role-players in this education.

9) Risk analysis represents fields that can effectively support the on-farm decision-making process and regulatory decision-making because they are much more focused on prospective action. An adapted HACCP system should be implemented in dairy farms and administered by a multidisciplinary team, supported by relevant regulations.

CHAPTER 7

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Appendix 1

APPENDIX 1

1 .1 FARMING SYSTEMS IN BENIN

a. Traditional transhumant farming systems in Benin (F5)

Plate 1.1: Transhumant herd drinking and watering directly into water point. Gogounou-Kandi

Plate 1.2: The same water point is used by human

<u>Plate 1.3</u>: Benin -Gogounou cattle market

<u>Plate 1.4:</u> Herd on pasture (Gogounou, Kandi)

b. Agro pastoral farming system in Benin (F6)

Plate 1.5: Herd in agro-pastoral Fulani camp Agro- pastoral mixed herd on pasture

Plate 1.6: entrance of an agro pastoral camp Gogounou- Kandi

Plate 1. 7: Traditional milking in the morning: Cows, calves, milk containers (Gogounou, Kandi)

Plate 1.8: Traditional hand milking in an agro-pastoral camp. The calf has just finish to suck the teat (Gogounou Kandi)

Plate 1.9: **Agro-pastoral herd (Borgou breed) going on pasture with children (Gogounou (Kandi)**

Plate 1.10: **Benin Gogounou livestock market Cattle. Holding and transport on a truck**

Plate 1.11: **Benin Kandi (Sori) Women selling wagashi (Beninese traditional cheese)**

Plate 1.12: **Containers in a small improved traditional cheese factory**

c. State Farms in Benin (F7)

Plate 1. 13: **Cattle (exotic breed GIR) in the stable Kpinnou State farm**

Plate 1. 14: **Limestones in feeding trough - Kpinnou State farm**

Plate1. 15: Tap and sail for watering. State farm – Kpinnou

Plate 1. 16: Cowsheds and watering place. State farm-Kpinnou

<u>Plate 1. 17:</u> Heaps of manure on a artificial pasture State farm - Kpinnou

<u>Plate 1.18:</u> Manure stocked on the soil waiting for spreading.
State farm - Kpinnou

<u>Plate 1.19:</u> Exotic Gir breed cattle in cowsheds. State farm- Kpinnou

<u>Plate 1. 20</u>: Exotic breed *Gir* calves. State farm - Kpinnou

<u>Plate 1. 21:</u> **Exotic breed *Girolando* cows on pasture State farm- Kpinnou**

Appendix 1

2 FARMING SYSTEMS IN SOUTH AFRICA

a. Large scale commercial farming systems

Plate 2.1: Cow with pendulous udder and mastitis

Plate 2.2: Milk samples for residues analysis

Plate 2.3 **Large scale commercial dairy herd on wheatlands (Western Cape - South Africa)**

Plate 2.4: **Large scale commercial Jersey heifer on extensive irrigated pastures**

Plate2.5: Large-scale commercial dairy – milking parlour. Jersey cattle

Plate 2.6: Bulk tank in large-scale commercial farming system (Western Cape)

<u>Plate 2.7</u>: Cooler truck for milk transport

<u>Plate 2. 8</u>: Electronic milk recording. Dairy parlour with milking machine

<u>Plate 2. 9:</u> Electronic monitoring of milk production and quality.

<u>Plate 2. 10</u>: Electronic monitoring and cooling system on bulk tank

Plate 2. 11: **State diagnostic laboratory for monitoring**

Plate 2.12: **Discharge of effluents and waste water into water source**

b. **Commercial small scale farming system (F3)**

Plate 2. 13: **Small scale commercial dairy (Western Cape)**

Plate 2.14: **Cattle in stable**

Plate 2 .15: **Entrance to milk parlour**

Plate 2. 16: **Milk tank**

<u>Plate 2. 17</u>: Vaccinating dairy calves: Veterinary care

<u>Plate 2. 18:</u> Animal health care

Plate 2.19: **Drinking water for cows**

c. **Informal small scale farming system (F3)**

Plate 2.20: **Informal small scale farmer using milk urns to transport milk**

Plate 2 .21: Informal small scale farming system. Calve weaning late

Plate 2. 22: Informal farming system in South Africa

<u>Plate 2. 23:</u> Informal small-scale dairy cattle on pasture

<u>Plate 2. 24</u>: Informal dairy system hand milking

<u>Plate 2. 25</u>: Treating a dairy cow in the crush

<u>Plate 2. 26</u>: Informal sales of milk in South Africa

d. **Communal Farming systems (F4)**

Plate 2.27: Cows drinking from a polluted river

Plate 2. 28: Traditional communal herd with a vet

<u>Plate 2. 29:</u> Traditional communal herd drinking from vlei

APPENDIX 2

APPENDIX 2

Laws and regulations in SA and Benin

Overview of National and international legislation relevant to dairy and water pollution in SA and in Benin

Table 2.8: (a) National legislation relevant to dairy systems and dairy production in SA

Name of Legislation	Number and date	Applicability	Responsibility	Institution	Observation
• The Health Act	1977(Act 63 of 1977) has been reviewed (Act 61 of 2003)			DoH	
• The Foodstuffs, Cosmetics, and Disinfectants Act	Act, 1972 (Act 54 of 1972		The local authorities of Health Departments	DoH	Has been revised for milk and milk derived products this year.
• Government notice on the regulation related to milk and dairy products	R 1555 of 21 Nov 1997	Determines the quality parameters of the different classes of milk and dairy products; it also describes the requirements for laboratory tests.	As above	DoH	
• Government notice as amended is the regulation governing Maximum Limits for Veterinary Medicine and Stock Remedy Residues that may be present in Foodstuffs.	No R.1809 of 3 July 1992	Guidelines for presumptive tests related to antibiotics, other antimicrobial substances and other residues that exceed the maximum levels	As above	DoH	
• Regulation 918 Regulation 908 • Regulation[2] SANS 10049 (Regulation SABS 049	1999 27June 2003				These are related to HACCP

Source: NDA, 2005; DOH, 2006

[2] www.foodhygiene.co.za/about_haccp.htm -

Table 2.8: (b) National legislation relevant to dairy systems and dairy production in SA

• Government Notice: Amendment to the Regulation relating milk and dairy products	No759 of 2 July 2004	Gives amendments on tests methods of coliforms and *E coli* bacteria in raw milk and methods of plate count tests	The stakeholders	DoH	Observation
• The Agricultural Products Standards Act, 1990	Act119 of 1990 R2581	Amends many sections of the Marketing Act (Act 59 of 1968)		DoA	Classification for the products and the payment of milk, fraud and imitation issues
• Government Notice on Dairy Products.	R1469 of 26 August 1994	Concerns the Regulations Regarding Dairy Products and Imitation. This Act gives the requirements for the organoleptic, physical biological and chemical characteristics; details on nutritional quality of different types of milk and dairy products are also included in the Notice.	Directorate Of Plant And Quality Control	DoA	Inspectors involved in dairy products control are represented by Health inspectors, Veterinary officers, Microbiologists, Chemists and Food inspectors.

Source: NDA, 2005; DOH, 2006

Table 2.8: (c) National legislation relevant to dairy systems and dairy production in SA

Name of Legislation	Number and date	Applicability	Responsibility	Institution	Observation
• The Conservation of Agricultural Resources Act, 1983.	1983	All import/export issues related to milk dairy products and the local distribution network Implementation of food quality standardization	-The Perishable Products Export control Boards (PPECB)	DTI	Process of registering as an international quality management organization
• SABS49-1989 for food hygiene and GMP		Review of the Codes of practice. Thus, this institution revised codes of practice SABS49-1989 for food hygiene and GMP			Revised

Source: NDA, 2005; DOH, 2006

Table 2.9: International legislation relevant to dairy systems and dairy production and other regulations in SA

Name of Legislation	Number and date	Applicability	Institution
• Agenda 21	1992	Action plan adopted	OIE, FAO, WHO WTO, CGIAR
The agricultural sector Plan adopted in 2001	2001	DoA	United Nations (UN) Conference on Environment and development (UNCED) in Rio de Janeiro
• The GMO Act, 1997 implemented in1999.	Act 15 of 1997	DoA	
• Convention on Biodiversity	1992		
• Norm ISO		ISO 9000 standards, HACCP and quality management systems on food safety	SA Bureau of Standards (SABS

Source: NDA, 2005; DoH, 2006

Some of the laws and regulations which are not specific to dairy issues are used for the implementation of the national basic laws.

Table 2.10 below contains the available non specific regulations on food of animal origin, in force in Benin, which can be used at a certain level for dairy issues.

Table2.10: (a) National legislation relevant to dairy systems and dairy production in Benin

Name of Legislation	Number and date	Applicability	Responsibility	Institution	Observation
• Decree relating to the organization of the Ministry of Agriculture, Livestock and Fisheries		Improvement of national production, control of the hygiene and sanitation of animals and animal foods origin.	Directorate of Livestock (DE), the National Agricultural Research Institute (INRAB) and the Regional Services of Animal Production and Health	• The Ministry of Agriculture, Livestock and Fisheries (MAEP)	ND
• Government Notice relating to the organization of the Directorate of Nutrition and Applied Alimentation		Improvement, monitoring of nutritional quality of food in general and then dairy products specifically	Directorate of Nutrition and Applied Alimentation (DANA)	• The Ministry of Agriculture, Livestock and Fisheries (MAEP)	Benin is member of Codex. However the National Commission of Codex created in 1985 is not functional
• Government Notice relating to the organization of the DPQC		Quality control of food in general (Assurance quality)	DPQC	• The Ministry of Agriculture, Livestock and Fisheries (MAEP)	DPQC is more involved in SPS. Active Association of Consumers HACCP in dairy field not yet implemented. Three laboratories are getting through the process of certification for food.
Decree relating to the organization and the functionality of National Commission of Codex Alimentarius	85-240 of 14 June 1985	Respect for the norms of Codex for all imported and exported food	All the national institutions concerned by food issues	Ministry in charge of Agriculture	Needs to be updated

Source: MAEP, 2004

Table 2.10: (b) National legislation relevant to dairy systems and dairy production in Benin

Name of Legislation	Number and date	Applicability	Responsibility	Institution	Observation
• Decree relating to the organization and the functionality of the Technical Committee of Food	85-239 of 14 June 1985 85-243 of 14 June 1985	Monitoring of all food control systems	Representatives of All the national institutions concerned by Food issues	Ministry in charge of Agriculture	Needs to be updated
• Decree relating to Hygiene of production and commercialization of food	No 72-31 of 27 September 1972	Norms of hygiene in food control systems (food of animal origin, food of vegetable origin seafood).	All the national institutions concerned by Food issues	Ministry in charge of Agriculture	Needs to be updated
• Ordinance Decree) relating to the regulation of Animals' Health Police and Inspection of animal origin food.		Lists the reportable animal diseases and the procedure for the notification and the control of milk and dairy products by the vet officers	DE, CeRPA (formally CARDER), Breeders and all animal owners	The Ministry of Agriculture, Livestock and Fisheries (MAEP)	Needs to be updated

Source: MAEP, 2004

Table 2.10: (c) National legislation relevant to dairy systems and dairy production in Benin

Name of Legislation	Number and date	Applicability	Responsibility	Institution	Observation
• Government Notice relating to the organization of the CEBENOR		Standardization and certification of food. Benin is member of ISO The import of dairy products are included	CEBENOR, laboratories, factories and industrials, Consumers	The Ministry of Industries Trade and employment promotion (MICPE)	
• Law relating to the conditions of trade in Benin	No 90-005 May 1990	Determines the conditions of delivery, use and safety control of milk, dairy products in Benin		The Ministry of Industries Trade and employment promotion (MICPE)	
• Public Health Act	No 87-015 (21 September 1987).			The Ministry of Public Health MSP	Needs to be updated
• Decree relating to the zoo sanitary regulations of • Animal Diseases in Republic of Benin	2005-637 of 13 October 2005	Regulation of reportable OIE Diseases	DE, Veterinary services and all institutions concerned by Zoonoses	MAEP,MSP, MISD, MEHU	Needs to be updated
• Food Control Act	Law No 84-009 of 1984	Overview of all legislation all types of food (including dairy)	All governmental institutions involved in food control; all stakeholders involved in the dairy chain food supply	MAEP, MCIPE, MSP.	Needs to be updated
• Law relating to the vain pasture, surveillance(guard) of animals and transhumance	Law No 87-013 of 21 September 1987	Use of natural pastures, the herding of domestic animals and transhumance	DE, CeRPA, Departments	MAEP, MISAT	Needs to be updated

Source: MAEP, 2004; MICPE, 2004; MSP, 2004; MEHU, 2004

Table 2.10: (d) National legislation relevant to dairy systems and dairy production in Benin

Name of Legislation	Number and date	Applicability	Responsibility	Institution	Observation
• Regulation relating to the creation, organization and functioning of Transhumance Committees	No 010/MISAT/MDR/ DCAB of 20January 1992	Creation of the committees for Transhumance at the National, Departmental and local level	DE, CeRPA, Prefectures	MAEP/ MIST	Needs to be up dated
• Regulation relating to the organization of transhumance	039/MISAT/MDR/ DCAB of 31 March1994	Determines the compulsory frontier posts, pasture areas, taxes and all the conditions of transhumance		MAEP/ MIST	
• Decree relating to the creation, organization and functionality of the National fund for fight against Epizooties (FLNE)	Decree No 2002-370 of 22 August 2002		DE		
• Regulation relating to the creation of the national Center for epidemiological surveillance and food hygiene	No392/MDG/SG/CC/CP of 24 September 1998	Determines various financial procedures to deal with zoonoses. All stakeholders are involved.	DE		
• Regulation relating to the importation of Veterinary drugs	No 425/ MDR/MSP/ MF/MCAT/ SG/CC/CP of 07 October 1998		DE		
• Regulation creating organizing and regulating the functioning of the Technical Commission of Veterinary drugs (CTMV	No 2004-516/ MAEP/D-CAB/SGM/DE/SA of 15 April 2004		DE/National vet chemistry/ National Directorate of chemistries		
• Regulation relating the Registration of stocks remedies and veterinary drugs in Benin	No 517/MAEP/D-CAB/SGM/DRH/DE/SA of 2004				

Source: MAEP, 2004; INSAE, 2005

Table 2.11 is related to the international legislation in force in Benin

Table 2.11: International legislation relevant to dairy systems and dairy production in Benin

Name of Legislation	Number and date	Applicability	Responsibility	Institution
Decision A/DEC.5/10/98 relating to the Principles of the regulation of the inter-States transhumance in the states Members of the CEDEAO/ECOWAS	31 October 1998	The International Certificate of transhumance is compulsory for all the transhumant herds. Determines the regulation for all the owners (art 5 and 12)	All the countries of the ECOWAS	• CEDEAO/E COWAS (Communauté Economique des Etats de l'Afrique de l'Ouest/ Economic Community of Western Africa States) • CEBV (Meat and Livestock Economic Community) • CIRDES (Inter Regional Center for the Development of Livestock in Sub-humid area) • UEMOA (Western Africa Economic and Financial Union)

Source: MAEP, 2004; INSAE, 2005

Table 2.12: National legislation relevant to environmental issues and water pollution in SA: Institutions involved

Level	Number and date	Applicability	Responsibility	Institution
National level		Coordination of EIA Environmental impact assessments	In charge of environmental quality and protection	DEAT
National level		EIA is handled by the private sector	The Committee for Environmental Affairs	DEAT (EIA, 2005).
National level		Monitor water pollution.		DEAT and DWAF
National level		Advise the MEAT on environmental-management issues	Directorate of Pollution and Waste Management (DEAT)	DEAT
			The National Environmental Advisory Forum (stakeholders and experts)	DEAT

Source: NDA, 2005; DOE, 2006; DWAF, 2005, 2006

Table 2.12: (a) National legislation relevant to environmental issues and water pollution in SA: Institutions involved

Level	Number and date	Applicability	Responsibility	Institution
Regional level		Independent statutory organizations.	The provincial conservation agencies	MEAT
		Governance of water quality management of SAn's water resources and forests (DWAF, 2005; SA Government, 2005). Implementation of Water Act Ensure equitable access to water and sanitation	The Directorate of Water-Quality Management Department of Water Affairs and Forestry (DWAF) acts against polluters)	DWAF DWAF
		Agricultural extension with the aim of improving irrigation efficiency	The National and Provincial Departments of Agriculture (NDA and PDA)	DoA
		Settlement of new farmers		DLA
International level				International Organizations

Source: NDA, 2005; DOE, 2006; DWAF, 2005, 2006

Table 2.12: (b) Legislation relevant to environmental issues and water pollution in SA.

Name of Legislation	Number and date	Applicability	Responsibility	Institution
The Conservation of Agricultural Resources Act, 1983	1983	As amended, details specific requirements and prohibitions applicable to land users.		DoA
• Hazardous Substances Act, No. 15	No 15 of 1973 Amended No 53 of 1992			
• The National Constitution of the RSA • Local Government Transition Act	Act 108/1996 209/1993	Amended: Government can control products even before they become waste.		DEAT
o Environmental Conservation Act (part 1, 3, 4, 5 and 6) • National Environmental Management Act, 1998) o EIA regulations o The Implementation Plan	Act 73 of 1989 Act 107 of 1998	Settlement of principles for effective management of the environment. Requires compilation of Implementation Plans (EIPs) and Environmental Management Plans, providing a legal framework for environmental development In accordance with the National Environmental Management Act, 1998. Includes programs to deliver water, energy, healthcare and targets for the reduction of poverty and protection of the environment.	Decision-making of all organs of the State National and provincial environmental Departments	DEAT
• National Water Policy,*1997* • National Water Act, 1998	1997 36/1998	Settlement of basic policy and legislation Protection, use, development, conservation, management and control of SA water resources. Integrated management of surface water and groundwater Sustainable use of surface and groundwater. Devolution of surface and groundwater to catchments at local level Registration of water-use is one of these tools.	Department of Water Affairs	DWAF

Source: DWAF/ Direction of Water quality management, 2006

http://www.dwaf.gov.za/Dir_WQM/index.htm

<u>Table 2.12:</u> (c) Legislation relevant to environmental issues and water pollution in SA.

Name of Legislation	Number and date	Applicability	Responsibility	Institution
		Assessment of the environmental requirements of the rivers and streams before a license can be issued.		DWAF
<u>Water Services Act, 1997</u> May become the more powerful regulatory tools available to national government.	108/1997	Government to play a support role through functions such as promoting awareness, information provision and capacity-building.		
• The Free Basic Water (FBW) Policy officially	Launched in July 2001	Production by water-services authorities of Development Plans, within the framework of Integrated Development Plans Regulation of the water boards		Distinction between local (the water-services authority) and national regulation However, in the short and medium term, the DWAF will be the national regulator of water services.
• Strategic Framework for Water Services (SFWS) September 2003.	Approved by Cabinet	The SFWS is what was previously referred to as the White Paper on Water Services consolidates all policy changes since 1994; it is a comprehensive strategic framework for the water-services sector as a whole.		
The National Water Resource Strategy	September 2004.	SA reached one of the first targets set in the Johannesburg Plan of Action, adopted at the *<u>2002 World Summit on Sustainable Development</u>*		
National Pricing Strategy for Raw Water	Implementation began in 2002	Ensure that the costs of the management of water resources and water-supply infrastructure are borne by water users.	"User pays: "Polluter pays"	

<u>Source</u>: DWAF/ Direction of Water quality management, 2006

<u>http://www.dwaf.gov.za/Dir_WQM/index.htm</u>

Table 2.13: International legislation relevant to water pollution in SA

Name of Legislation	Number and date	Applicability	Institution
• Agenda 21 • Plan of Action, adopted International agreements related to environment and water pollution. • RAMSAR Convention • Frame Convention on Climate change • Convention for Fight against Desertification	1992 2002 1971 1992 1994	Global strategy for sustainable development Several bilateral and multilateral relationship with different countries in Southern Africa and in the continent	The United Nations (UN) General Assembly Conference on Environment and Development World Summit on sustainable development (Johannesburg)

Source: DWAF/ Direction of Water quality management, 2006

http://www.dwaf.gov.za/Dir_WQM/index.htm

Table 2.14(a): National legislation relevant to water pollution in Benin: the institutions

Name of Legislation	Number and date	Applicability	Responsibility	Institution
• Constitution of Republic of Benin • Decree relating to the organization of the Ministry of Mines Energy and Water (MMEE) formally MMEH	90-32 of 11 December 1990 2005-191 of 14 April 2005		The General Directorate of Hydraulic -The Technical Secretariat for the Promotion and the Coordination of the GIRE (STPCGIRE) -Departmental directorates of the MMEE	The Ministry of Mines, Energy and Hydraulic (MMEH) currently MMEE

Source: MMEH, 2005

Table 2.14: (b) National legislation relevant to water pollution in Benin: the institutions

• Decree relating to the Ministry of Health (formally Ministry of Public Health)			The Directorate of Hygiene and the Service of the Sanitary Police	Ministry of Health
• Decree relating to the organization of Industry and Trade (MIC), formally MCIPE			Local communities, the civil society and the Association of Consumers	
			Private institutions The NGO's (national and international). Partnerships for development	Cooperation with France, Denmark, Netherlands, Germany, Belgium, World Bank, PNUD/, UE/EU (European Union), GWP.
• Decree relating to the creation, organization and functioning of the Environmental Police	2001-096 of 20/02/2001.	Inspection and control of water resources quality.	-Judicial, Health Police and Environmental Police	MJL, MS, MEN

Source: MMEH, 2005

Table 2.14: (c) National legislation relevant to water pollution in Benin: Laws/Regulations/Norms

Name of Legislation	Number and date	Applicability	Responsibility	Institution	Observation
• Frame Act of Environment in Republic of Benin	98-030 of 12 February 1999	Determines the basis of National Environmental Policy and strategies	Everybody living in Benin is subject to this Law	Government of Republic of Benin	
• Food Control Act	84-009 of 1984			MAEP, MEN	
• Public hygiene Code	87-15 of 1987				Under review
• WaterCode	987-016 of 1987				Under review Chap 2 (Art 23-380: protection measures of continental water plans and Art 39-44: maritime water plans) and Title 3; about protection and development of lands and human environment
• Environmental audit procedure Decree	2001-93 of 2001				
• Environmental impact assessment procedure Decree	87-93 of 2001				
• Table Water quality norm	2001-094				
• Waste water norm	109 of 2001				
• Environmental Cells (Regulation	375/MAEP/D-CAB/SGM/DPP/DA/CRH/SA of 2002				

Source: Aquastat, 2005; MMEH, 2005 ; MEHU, 2003
http://www.fao.org/ag/agl/aglw/aquastat/countries/benin/indexfra.stmInstitutions

Table 2.15: International regulation relevant to water pollution Benin

Name of Legislation	Number and date	Applicability	Responsibility	Institution
• RAMSAR Convention • Convention on Biodiversity • Frame Convention on Climate change • Convention for Fight against Desertification	1971 1992 1992 1994			

Source: Aquastat, 2005 *http://www.fao.org/ag/agl/aglw/aquastat/countries/benin/indexfra.stmInstitutions*