LIVESTOCK DENSITY AND NUTRIENT BALANCES ACROSS ASIA.

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Abstract

Livestock production is developing very fast in most parts of Asia, driven by a booming demand. The increase is mainly supported by industrial systems, with series of environmental impacts, among which nutrient overloads is probably the most severe. The purpose of the current study is to asses the geographical pattern of this issue across East, South and Southeast Asia. A combination of nutrient mass balances and spatial modelling was performed. The study shows that along with high livestock densities, large percentage of surfaces are presenting nutrient overloads, particularly in South East Asia. It also clearly reveals the peri-urban phenomenon. Contribution of manure to nutrient supply was identified as being more critical in areas with low overloads than in areas with important overloads.

Key words: nutrient balance, GIS, Asia, nutrient surplus, livestock density.

Introduction

The term ‘Livestock revolution’ has been used to describe the rapid expansion of livestock production in developing countries, which has mainly been fuelled by population growth, urbanisation and income growth in developing countries (Delgado et al, 1999). Among the developingworld, South East Asia has the fastest developing livestock sectors e.g. it is growing at 3.2% per year compared to 1.7% for the whole world. This rising demand for animal products is being met mainly by a rapid growth of specialised intensive pig and poultry production (annual growth rate 17.7%; Steinfeld, 2001). Industrial systems are primarily directed at producing animal protein at low prices for the urban markets. Since they are demand-driven, intensive animal production and processing often take place near urban areas, while primary feed is produced in distant rural areas or imported. As such systems depend on outside supplies of feed, energy and other inputs, their impact on the environment can also affect regions other than those where production takes place. Furthermore, the impact on the environment depends on the animal species, the production technique and the type and processing of feed, products and by-products.

The main environmental problems associated with industrial livestock production systems are: 1) accumulation of animal waste, leading to build up of excess nutrients and heavy metals in the soil, 2) pollution of surface and ground water with nutrients (eutrophication), heavy metals and pathogens, 3) emission of ammonia, odour and greenhouse gases (methane, nitrous oxide) to the atmosphere,4) release of chemical inputs, feed additives and animal health inputs, tannery and slaughter house wastes, 5) degradation and depletion of fresh water resources, 6) high consumption of fossil energy leading to CO_2 emission and global warming and 7) loss of bio-diversity in farm animals. Nutrient overloads and emissions occur especially if the nutrients present in manure are not properly recycled or treated. The major effects of animal waste miss-management on the environment have been summarised by Menzi (2001):

Eutrophication of surface water (deteriorating water quality, algae growth, damage to fish etc.) due to input of organic substance and nutrients if excreta or waste water from livestock production get into streams through discharged, run-off or overflow of lagoons. Surface water pollution threatens aquatic ecosystems and the quality of drinking water taken from streams.

Leaching of nitrate and possibly pathogens to the ground water from manure storage facilities for liquid manure or from fields on which high doses of manure have been applied. *Accumulation of nutrients* and heavy metals in the soil if high doses of manure or manure with excessive heavy metal content are applied. This can threaten soil fertility. Of significance are the heavy metals that are added to the animal feed in therapeutic doses or as growth promoters, especially copper (Cu) and zinc (Zn) and in some cases chromium (Cr) and cobalt (Co).

The work of the "Livestock, Environment and Development Initiative (LEAD) targets at the protection and enhancement of natural resources as affected by livestock production while alleviating poverty (http://lead.virtualcentre.org/selector.htm). In particular, the initiative is involved in developing tools to asses livestock – environment interactions for early warning and decision support with regard to policy making and activity targeting. In this framework, the objective of this study was to assess the spatial distribution of nutrient overloads, (nitrogen - N_{total}, phosphate - P_2O_5 and potash - K_2O) in Asia. Nutrient balances calculations compare the amount of nutrients entering the system to the nutrients leaving the system. They have been used to estimate nutrient flows at farm, regional and national level (Pirttijarvi, 1998). The estimation of nutrient balances provides an indicator of potential depletion, overload or equilibrium. The usefulness of this indicator with comparison to empirical approaches (e.g. soil or water sampling) are it's robustness and the possibility to calculate it on the basis of statistics, and thus for large areas.

Material and methods

The study was limited to South, East and Southeast Asia (SESE-Asia) as defined by FAOSTAT (2001). SESE-Asia was selected because of 1) highest growth worldwide in livestock production mainly due to rapid expansion of industrial systems, 2) high use of mineral fertilisers and 3) relative high livestock densities.

The balance was calculated at soil level, for a given area of agricultural land. It recognised two inputs (available manure and mineral fertilisers) and two outputs, that are crops uptake and use of manure as fuel (the latter is considered for nitrogen balance calculation only).

The countries were divided into two groups, based on the size and importance of the livestock sector. Group A comprised countries considered only at national level, while countries in group B (China, Laos, Indonesia, India, Malaysia, Mongolia, Thailand and Vietnam) were considered at province level. FAOSTAT (FAO, 2002) was mined to obtain comprehensive national statistics on livestock numbers and crop production for countries classified under group A. Primary data on both livestock and crop production for Group B were obtained from national statistical yearbooks and supplemented by web-sites. The data collected included livestock numbers by species (cattle, buffalo, sheep, goats, pigs and poultry), crop production, pastures and fertiliser consumption at the appropriate administrative level.
Modelling was performed in order to estimate the distribution of input data on a 0.05' by 0.05' grid. Animal densities pattern was estimated with the help of animal distribution models (FAO, 2001a). In the case of monogastric species, a specific model was prepared. The model recognises two types of animal production : backyard production (for which animal distribution is estimated as being directly related to rural population) and industrial production which is allocated to areas in the periphery of urban centres and close to infrastructure facilities. For each administrative unit, a share of industrial production, as well as the maximum distance of this type of production to urban area and infrastructure was estimated on the basis of economic indicators and FAO expertise. The geographical distribution of agricultural land and crops, was modelled on the

basis of Land Cover and Land suitability for cropping coverages (FAO, 2002). Mineral fertiliser, which statistical data was available at country level only, had been distributed on the basis of cropped areas and yields.

Excretions content in nitrogen (N_{total}), phosphate (P_2O_5) and Potash (K_2O) were estimated on the basis of model calculations and pilot projects results in Asia (Menzi, unpublished). For each livestock category, 3-4 levels of excretions were differentiated, depending on the weight of the animals and the production intensity. Nutrient uptake for crops were available at FAO (FAO, 2001b).

The balance was finally computed for each grid cell of the study area.

Results and discussion

Map 1 presents a rather unbalanced general pattern of total livestock P_2O_5 excretion distribution, with high concentrations in China, Korea, Japan and Vietnam, especially around urban centres (e.g Bangkok, Ho Chi Minh, Singapore, Shanghai, Beijing). Similar observation are made for Nitrogen. Map 2 shows that the contribution of monogastrics to phosphate excretion follows a West-East gradient. High values are observed in large parts of China, Vietnam, Malaysia, Indonesia and Japan and around urban centres. Map 3 displays strong heterogeneity across SESE-Asia regarding the P_2O_5 balance. Some areas present low crop and livestock densities, and are close to an equilibrium (Mongolia, West China). Others present both high livestock and crop densities, resulting rarely in equilibrium (parts of South China) or nutrient depletion (parts of India) and most often in overloads (East China, Japan, Ganges basin, South Korea, West of Java). High surplus is again often near urban centres like Shanghai, Beijing, Hanoi, Ho Chi Minh City, Bangkok, Calcutta. Map 4 shows that manure can represent a substantial source of phosphate, especially in those countries where mineral fertiliser consumption is low. We also observe that manure is generally not the major nutrient source in the areas with high overloads (>30kg/ha), but that it can play a critical role in areas with low overloads (10-30kg/ha).

The use of GIS for nutrient mass balances modelling over a large area allowed the improvement of the statistical input data and a highly informative display of the results of the calculation. Thus, the produced results and maps represent a useful decision support tool for policy making and targeted interventions. Furthermore, it provides good awareness building information. Further studies will be implemented in Latin America and Europe and to allow for cross continental comparisons. It is hopped that similar method will be used to study the development of the situation over the last decades.

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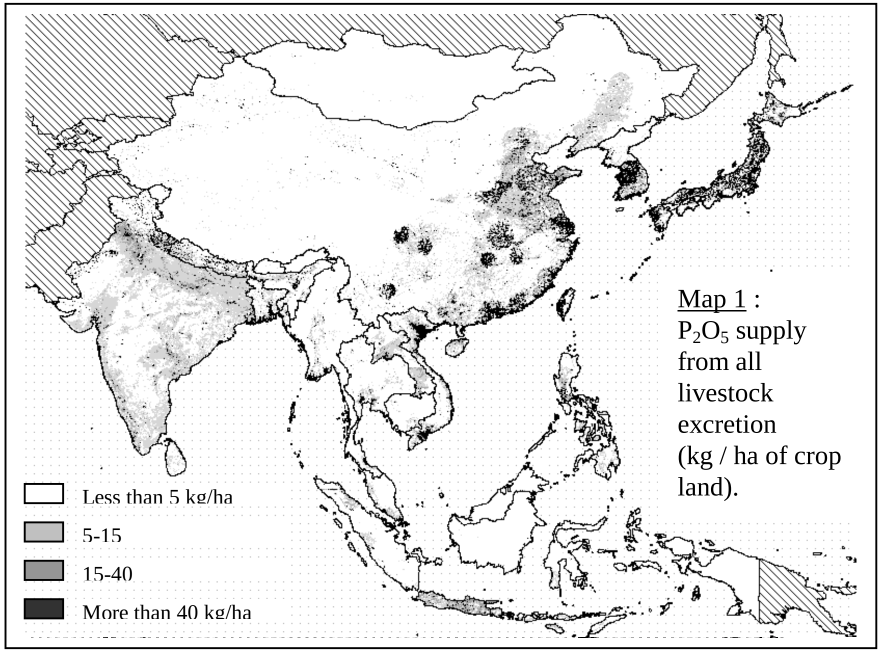
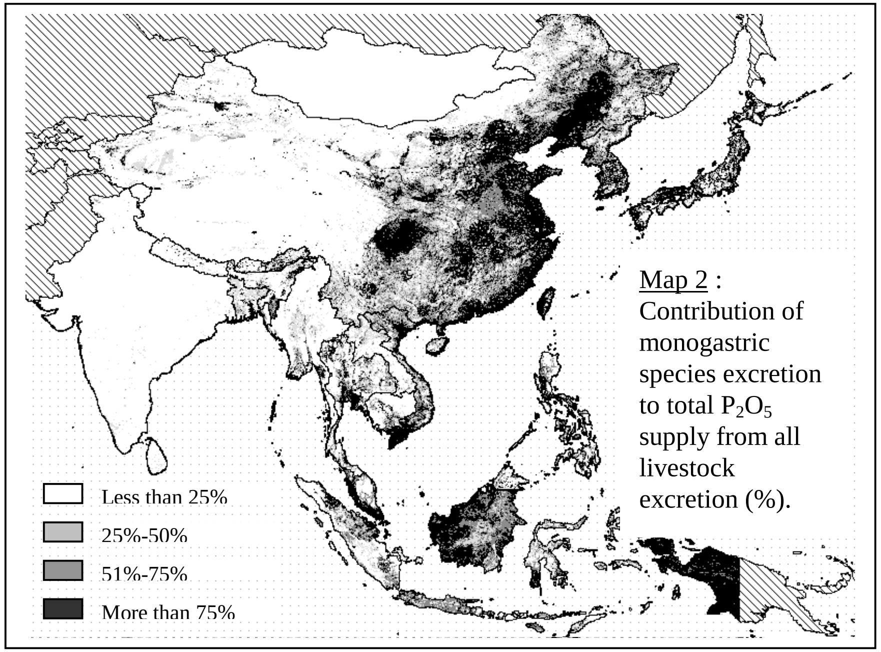
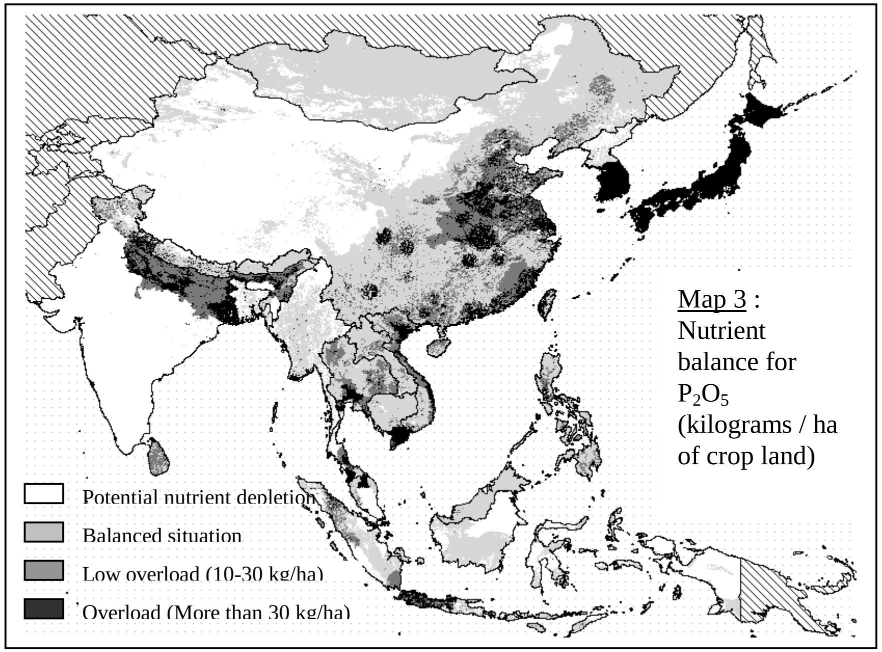


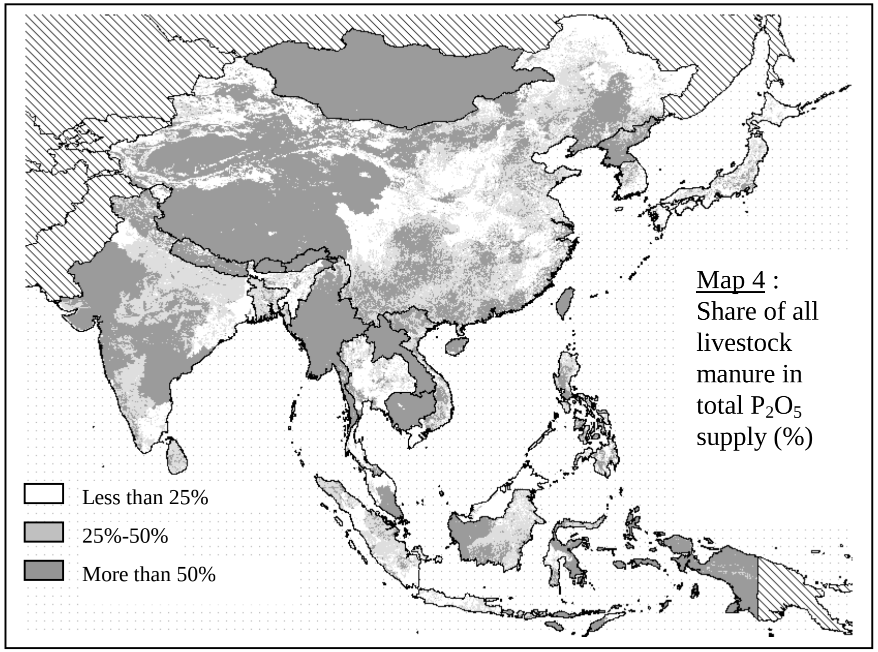
Map 1 : P_2O_5 supply from all livestock excretion (kg / ha of crop land).



Map 2 : Contribution of monogastric species excretion to total P_2O_5 supply from all livestock excretion (%).



Map 3 : Nutrient balance for P_2O_5 (kilograms / ha of crop land)



Map 4 : Share of all livestock manure in total P_2O_5 supply (%)