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Poultry Litter Affects Forage Dry Matter Yield and Total N and P Uptake

By Robert W. Taylor, Sidat Yaffa, David A. Mays , Teferi Tsegaye, Wubishet Tadesse & Karamat R. Sistani
Alabama A&M University, United States

Abstract- Forage crops play an important role in removing P and N from poultry litter-amended soils there byminimizing environmental pollution. A three year study was conducted at Crossville, AL to compare dry matter yield and total P and N removal efficiencies by forage crops from a poultry litter-amended soil. Forage crops including alfalfa (Medicago sativa, L.), rye (Secalecereale, L.), corn (Zea mays, L.), sorghum-sudangrass (Sorghum bicolor, L.) cv. Unigraze II, tall fescue (Festucaarundinacea, L.) cv. KY31, and Russell bermudagrass (Cynodondactylon, L.) were investigated. The soil type at the site was a Hartsells fine sandy loam (fine-loamy, siliceous, thermic TypicHapludults).

Keywords: *N, P, PL, forage crop.*

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POULTRYLITTERAFFECTSFORAGEDRYMATTERYIELDANDTOTALNANDPUPTAKE

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Poultry Litter Affects Forage Dry Matter Yield and Total N and P Uptake

Robert W. Taylor [α], Sidat Yaffa [σ], David A. Mays [ρ], Teferi Tsegaye [ω], Wubishet Tadesse [¥] & Karamat R. Sistani [§]

Abstract- Forage crops play an important role in removing P and N from poultry litter-amended soils there byminimizing environmental pollution. A three year study was conducted at Crossville, AL to compare dry matter yield and total P and N removal efficiencies by forage crops from a poultry litter-amended soil. Forage crops including alfalfa (Medicago sativa, L.), rye (Secalecereale, L.), corn (Zea mays, L.), sorghum-sudangrass (Sorghum bicolor, L.) cv. Unigraze II, tall fescue (Festucaarundinacea, L.) cv. KY31, and Russell bermudagrass (Cynodondactylon, L.) were investigated. The soil type at the site was a Hartsells fine sandy loam (fine-loamy, siliceous, thermic TypicHapludults).The highest dry matter yield in 2001 was observed with sorghum-sudangrass and in 2002 and 2003 it was observed with Russell bermudagrass, respectively. In 2001, the lowest dry matter yield was observed with alfalfa, in 2002 it was observed with corn, and in 2003 it was observed with sorghum-sudangrass, alfalfa, and Russell bermudagrass, respectively. Sorghum-sudangrass showed the highest N uptake in 2001, alfalfa and Russell bermudagrass showed the highest N uptake in 2002 and 2003, respectively. Tall fescue showed the highest P uptake in the three-year study. Russell bermudagrass appears to be the most effective forage crop for removal of N and tall fescue for the removal of P from soils amended with poultry litter.

Keywords: N, P, PL, forage crop.

I. Introduction

The rapidly expanding poultry industry in the state of Alabama, now ranked third in the United States behind Georgia and Arkansas in terms of broiler chicken (Gallusgallus, L.) production, is geographically concentrated in several areas of the state (Alabama Agric. Statistics Serv., 2004). About 1.8 million tons of poultry litter (PL) is produced yearly in Alabama, creating a major waste disposal problem. The disposal of this large amount of litter is confined mainly to relatively small areas of perennial tall fescue (Festucaar-undinacea, Schreb) pastureland (Molnar and Wu, 1989). Several counties in the Sand Mountain region of Alabama account for approximately 43% of the state's total broiler production and generate nearly 0.7 million tons of litter annually (Alabama Agric. Statistics Serv., 2004; Payne and Donald, 1990). Indiscriminate use of PL may lead to harmful effects on the environment. The main problems that can arise from excessive PL application on the land are pollution of both ground and surface waters due to leaching and runoff of nutrients and soil accumulation of heavy metals (Payne and Donald, 1990). According to Blitzer and Sims (1988), excessive application of PL in some forage cropping systems has resulted in NO-3-N contamination of groundwater. High concentrations of total P in surface waters, largely resulting from surface runoff of sediment-loaded P, causes eutrophication (Schindler, 1977; Sharpley et al., 1996).

Pastures are common sites for poultry litter applied as fertilizer on forages used for cattle (Bostaurus) grazing or hay production in Alabama. Cattlegrazing removes relatively few nutrients from the farm throughmilk or meat production (Ball et al., 1991). Nutrient amountstaken up by plants are similar to nutrient amounts releasedfrom manure deposited back on the pasture by animals grazingthe plants. Mechanical removal of harvested forage crops from thefarm will reduce the buildup of nutrients in soils fertilizedwith PL. Forage crops have been traditionally fertilized withPL to meet the plant N requirements. But, PL appliedto meet plant N requirement contains more P than required bythe plant and P buildup in the soil will occur (Kingery et al., 1993 and Sharpley et al., 1998). In many counties of Alabama, P from PL meets or exceeds plant uptake (Potashand Phosphate Inst., 1998). The effect of this excess P on waterquality is becoming a major concern in Alabama (Sharpley et al., 1998).

Research on nutrient uptake from soils treated with PLhas considered relatively few forage crops. In most cases studieshave used a single crop or mixture of crops as a catchcrop while evaluating other treatment variables (Vervoort et al., 1998). A study reported by Honeycutt et al. (1998) showed that forage dry matter yield of bermudagrass [Cynodondactylon (L.) Pers.] tall fescue (FestucaarundinaceaSchreb.) and a tall fescue–red clover (Trifoliumpratense L.) – whiteclover (T. repens L.) mixture was increased with increasingrates of PL. It was reported that plant N and P uptake increased withrate of PL application on bluegrass (PoapratensisL.) – tall fescue and bermudagrass–tall fescue pastures (Lucero et al., 1995; Vervoort et al., 1998). Kingery et al. (1993) reported that long-term PLapplication on tall

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fescue pastures increased plant N, P, andK concentration. There is a wide range of forage crops that are adapted for growth in the southeastern USA (Ball et al., 1991), but little is known about the nutrient uptake of these crop species under PL fertilization.

The objectives of this study were to (i) compare the dry matter yield of different forage crops and (ii) compare N and Puptake efficiencies of forage crops fertilized with PL.

II. Materials and Methods

a) Field Methods

The field experiment was initiated in September 1999 at Auburn University's Sand Mountain Research and Extension Center, which is located at Crossville, Alabama (latitude 34o 30' N and longitude 85o 50' W) on a Hartsells fine sandy loam (fine-loamy, siliceous, thermic TypicHapludults). The soil had been fertilized with PL at the rate of 5.6 Mg ha-1 yr-1 for 12 yrs. The soil test results in 1999 at 45 cm depth were: pH 5.8, P-215, K-465, Mg-263, and Ca- 1523 kg ha-1, respectively. Temperature and rainfall data were collected from the weather station at the research station. No supplemental irrigation was provided. The forage crops were Russell bermudagrass (Cynodondactylon, L.), sorghum-sudangrass (Sorghum bicolor, L.) cv. Unigraze II, alfalfa (Medicago sativa, L.), tall fescue (Festucaarundinacea, L.) cv. KY31, rye (Secalecereale. L.), and corn (Zea mays, L.). The fertilizer treatments were 0, 224, and 448 kg ha-1 P from triple superphosphate, which was applied at the beginning of the experiment in order to create a soil P variable. The experimental design was a randomized complete block design with four replications of 18 treatments per replication. The plot size was 2.1 m x 6 m with 3.6 m distance between tiers of plots.

The forages were planted thus: Tall fescue was planted in the fall with a no-till drill at 22.4 kg of seed ha-1, alfalfa was hand-planted on a tilled soil at 22.4 kg of seed ha-1 in the fall, corn was planted using a no-till drill in 90 cm rows at the rate of 62,000 plants ha-1, rye was planted by using a no-till drill at the rate of 22.4 kg of seed ha-1, bermudagrass was hand-planted by using sprigs at the rate of 134 kg of sprigs ha-1, and sorghum-sudangrass was planted by a no-till drill at the rate of 28 kg of seed ha-1. Forage was harvested by using a 1.5 m flail type plot harvester, weighed on an electronic scale, and sub-samples taken for dry matter determination. Tall fescue was harvested in mid-May, early July, and late October; alfalfa in May, June, July, and September; rye once in late April; corn once in August or September; sorghum-sudangrass and Russell bermudagrass three times at monthly intervals. The samples were finally dried in an oven at 49OC for 72 h, ground to pass a 2-mm sieve, and then used for chemical analysis.

Soil samples from the treatment plots were collected once at the beginning of the experiment with a hand-held auger from 0 to 100 cm depth, with 20 cm intervals as a baseline information on soil P and N. In successive years of the experiment, soil sampling was done with the same auger but only two depths (0 – 30 and 30 – 45 cm) were considered for soil P and N determination. The soils were collected at the beginning of and at the end of each growing season.

b) Laboratory Analyses

There were two analyses methods employed for extracting total N and P from both plant and soil samples: total P (Digestion first then Murphy – Riley Method, using a spectrophotometer (Spectronic 501&601 model by Milton Roy)) and total N (using Kjeldahl Method (Kjeltec Auto 2400 Analyzer)).

c) Statistical Analyses

Data for soil and plant parameters were analyzed statistically using the MIXED procedure of SAS (Little et al., 1996). Sources of variation included forage crop, P and N fertilization, date of sampling, and their interactions. The least square means test was used to determine the significant difference between the means when treatment interactions were significant. Correlation analysis was used to determine the relationship between forage crop dry matter yield, soil N and P, forage N and P uptake on mean values of 4 replications. Statistical significance was set at $P \leq 0.05$

III. Results and Discussion

a) Climate

The temperature and rainfall from 2001 to 2003 near the field study site are shown in Fig. 1a and Fig. 1b. The highest monthly temperature was observed in July of each year (21oC) and the lowest temperature was observed in January of each year (0 to -1oC) (Fig. 1a). The average monthly rainfall for January, 2002 and for April, 2003 were the highest for the study period (Fig. 1b). The lowest monthly rainfall was observed in October 2001 and 2002, respectively and in January 2003. Total rainfall was 128 cm for 2001, 125 cm for 2002, and 176 cm for 2003, respectively.

b) Baseline Soil Total N and P (%)

There was a significant difference in the amount of baseline soil total N (%) and total P (%) in 2001 as influenced by depth (Table 1). We found that as soil depthincreased, the amount of soil total N and P decreased significantly because P has been shown to be relatively immobile and because of accumulated organic matter from dead roots and other decayed plant parts is greater near the soilsurface. For example, we found that the amount of total N in the first 20 cm of the soil profile was more than twice what was found in the 80-100 cm depth. The first 20 cm depth of the soil had over three times as much total P as the 80-100 cm depth showing that P does not move much in the soil

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and accumulates in the surface layers. This finding agrees with the work of Holford (1997).

c) Total Annual Forage Dry Matter Yield (kg ha-1) in 3-yr

The highest annual forage dry matter yield over four replications in 2001 was observed with sorghum-sudangrass (8,000 kg ha-1) and the lowest yield was observed with alfalfa (2,000 kg ha-1) (Fig. 2). In 2002, the highest forage dry matter yield was observed with Russell bermudagrass (19,000 kg ha-1), and the lowest dry matter yield was observed with corn (4,000 kg ha-1). Finally, in 2003, the highest forage dry matter yield was observed with Russell bermudagrass (13,000 kg ha-1) and the lowest dry matter yield was observed under sorghum-sudangrass (3,000 kg ha-1), alfalfa (3,000 kg ha-1), and rye (5,000 kg ha-1), respectively. Except for corn, which had a poor stand, all the other crops had the highest dry matter yield in the second year of the study. There was a significant difference in forage dry matter yield between Russell bermudagrass and the rest of the crops in 2002 and 2003 (Fig. 2). In 2002, Russell bermudagrass total dry matter yield (19,000 kg ha-1) was 47% more than sorghum-sudangrass and tall fescue (10,000 kg ha-1, respectively), 53% more than alfalfa (9,000 kg ha-1), 79% more than corn (4,000 kg ha-1), and 66% more than rye (6,500 kg ha-1) (Fig. 2). In 2003, the same Russell bermudagrass total dry matter yield (13,000 kg ha-1) was 69% more than sorghum-sudangrass and alfalfa (4,000 kg ha-1, respectively), 38% more than tall fescue (8,000 kg ha-1), 15% more than corn (11,000 kg ha-1), and 62% more than rye (5,000 kg ha-1) (Fig. 2). There was no significant difference in forage dry matter yield between sorghum-sudangrass, tall fescue, and alfalfa in 2002. Corn (4,000 kg ha-1) in 2002 and alfalfa (4,000 kg ha-1) and sorghum-sudangrass (4,000 kg ha-1) in 2003 produced the least amount of forage dry matter yield. This was because in 2003 most of the forage crops had already reached their maturity stage of growth and therefore absorbed less nutrients and moisture from the soil and/or the soil was depleted of nutrients to support more forage growth.

d) Total Forage Dry Matter Yield (kg ha-1) in 3-yr

The total forage dry matter yield for the experiment was as follows: Russell bermudagrass had the highest total dry matter yield (37,880 kg ha-1) and rye (11,378 kg ha-1) for 2 yrs only) was the lowest (Fig. 3). Total dry matter yield for Russell bermudagrass was significantly higher than the rest of the forage crops. There was no significant difference in total dry matter yield between sorghum-sudangrass (20, 793 kg ha-1) and tall fescue (23,182 kg ha-1) and between alfalfa (14,448 kg ha-1), corn (12,880 kg ha-1), and rye (11,378 kg ha-1), respectively (Fig. 3). Growing rye and sorghum-sudangrass as winter and summer crops on the same plots produced the second highest total dry matter yield per year. Total Russell bermudagrass yield was 45% more than sorghum-sudangrass, 39% more than tall fescue, 62% more than alfalfa, 66% more than corn, 70% more than rye, and 15% more than rye and sorghum-sudangrass together. This shows that Russell bermudagrass has a high potential for being used as a suitable forage crop for dry matter yield purposes.

e) Total Forage N and P Uptake (kg ha-1) from 2001 – 2003

Total N uptake (kg ha-1) for each forage crop in each year over average of all P rates were measured (Table 2). In 2001, we found a significant difference in total N uptake between sorghum-sudangrass and the other forage crops. This could probably be due to the quick establishment of sorghum-sudangrass than the other forage crops. There was no significant difference in total N uptake between Russelbermudagrass, tall fescue, and alfalfa in 2001 (Table 2). Total N uptake could not be measured for corn and rye because the two forage crops were a replacement for eastern gamagrass (Tripsacumdactyloides, L) and triticale (Triticale hexaploide, Lart), respectively, in years 2 and 3. In 2002, alfalfa exhibited the highest total N uptake (340 kg ha-1) and corn the lowest (18 kg ha-1) (Table 2). Alfalfa is a nitrogen-fixing crop and that could be the reason for its high N uptake than the rest of the forage crops in 2002. There was a significant difference in total N uptake between alfalfa and the rest of the forage crops (Table 2). Overall, there was a significant difference in total N uptake between all the forage crops in 2002. In 2003, tall fescue showed the highest total N uptake (182 kg ha-1), which was significantly different from the rest of the other forage crops, and sorghum-sudangrass showed the lowest total N uptake (20 kg ha-1) (Table 2). We found no significant difference in total N uptake between sorghum-sudangrass and corn and between corn and rye in 2003 (Table 2). Except for sorghum-sudangrass, total N uptake was lower for all forage crops in 2001 than in 2002 and 2003. This is probably because the crops were not fully established in 2001 and they yielded less than in later years and therefore took up less N. Across all forage crops, total N uptake was highest in 2002 than in 2001 and 2003 (Table 2). This was probably because the crops had established vigorous root systems in 2002 than other years and therefore they were able to uptake most N.

We found no significant difference in total P uptake between Russell bermudagrass and sorghum-sudangrass in 2001 (Table 3). Total P uptake was not measured for corn and rye because they were not planted in 2001 as for the same reason explained under total N uptake. There was no significant difference in total P uptake between Russell bermudagrass, sorghum-sudangrass, and tall fescue in 2002. Corn, on the other hand, showed the lowest total P uptake in

2002 (Table 3). The highest total P uptake in 2003 was exhibited by tall fescue (29 kg ha-1), which was significantly different from the rest of the forage crops. Also, there was no significant difference in total P uptake between Russell bermudagrass and alfalfa and between corn and rye (Table 3). For all forage crops except for corn, total P uptake was higher in 2002 than in 2001 and 2003, respectively (Table 3). This was due to all the crops except corn yielding more forage in 2002 than in 2001 and 2003. Tall fescue was the only crop that maintained a somewhat consistent total P uptake from 2001 to 2003. This suggests that tall fescue could be used as a suitable forage crop for total P removal from soils amended with excess poultry litter.

IV. Residual Total Soil N and P in Percentage

Residual total soil N (%) and P (%) were measured for two years (2002 and 2003). The level of soil N and P (%) at 0-30 cm and 30-45 cm depth was determined. Except P treatment, depth*P treatment, and P treatment*year, we found that depth, crop, year, depth*crop, and crop*year interactions were significant at $P \leq 0.05$ for soil N. (Table 4). The soil samples were collected after each forage harvest in 2002 and 2003 to determine how much N and P were left in the soil as residual N and P. There was a decrease in N (54%) between 0-30 cm and 30-45 cm depths in both years (Fig. 4). We found more N in the 0-30 cm depth (0.11%) than in the 30-45 cm depth (0.05%) (Fig. 4). Another reason for this difference in soil N could be that the 0-30 cm depth had much more living and dead-decomposing plant roots than the 30-45 cm depth. This was probably due to the accumulation of foliage on the soil surface from the previous 2-yr and followed by the slow mineralization of PL that was applied to the soil surface. Also most roots are found in the top 30 cm of the soil. This finding is similar to work done by Sistani et al. (2004), who studied soil nutrient dynamics in Bowling Green, KY. and found that total N content for 0-5 and 5-10 cm soil depths was 1.50 and 0.50 g kg-1, respectively, in January 2000. They concluded that high N concentration in the soil surface was due to surface application of broiler litter without any incorporation. Nitrogen leaching in the NO-3-N form is a known research fact. However, total N in this study includes both organic and inorganic N that is found in both fresh and decomposed organic matter which does not leach much. Thus, total N would be expected to be higher at the soil surface.

Soil N under various summer growing forage plots ranged from 0.06% to 0.08% as follows: alfalfa (0.08%), tall fescue (0.06%), Russell bermudagrass (0.07%), sorghum-sudangrass (0.07%), corn (0.06%), and rye (0.13%) (Fig. 5). Soil under rye had the highest residual N concentration (0.13%) and was significantly different from the rest of the forage crops (Fig. 5). This could mean that rye removed less N from the soil. The ability of a forage crop to remove more N from the soil depends on the crop species, the maturity of the crop when harvested and the amount of N supply in the soil. For example, compared to tall fescue, soil under rye had about 42% more residual N at the end of the study. There was no significant difference in soil N under alfalfa (0.08%), bermudagrass (0.07%), and sorghum-sudangrass (0.07%). Finally, soil N under bermudagrass, sorghum-sudangrass, corn, and tall fescue were not significantly different although bermudagrass had the highest residual soil N. In soils under grasses, N concentration is determined by plant uptake, NO3--N leaching and also depends on the amount of available N in the soil. In soils under legumes like alfalfa, the amount of N concentration also depends on the amount of N in the soil. However, fixation of N in legume nodules provides the rest of the N needed, resulting in soils under legumes having a more constant N supply regardless of soil N availability. It is important to note that total N measurements cannot be used as an index of N movement because N movement is determined by measuring NO-3-N. So, there could have been leaching of N as NO-3-N(Tsegaye et al., 2002; Boggs et al., 2001). The year 2002 had about 22% more N (0.09%) in the soil as residual N than in 2003 (0.07%) (Fig. 6). This could be due to slow mineralization or immobilization of N from accumulated foliage on the soil surface in 2002 than in 2003, N leaching due to greater rainfall in 2003 than in 2002 (Fig. 1b), or N loss due to volatilization .

Depth, crop, and crop*year interactions were the only significant variables for residual total soil P (Table 4). The P treatment applied at the beginning of the study to create a P variable did not have a significant effect on soil N (data not shown). This suggests that inorganic P application to a soil that already has received PL over years will not have any significant effect on soil N. There was no significant difference in residual soil P at 0-30 cm depth (0.02%) and at 30-45 cm depth (0.01%) for the 2-yr study (Fig. 6). This was due to lack of downward movement of P in the 30-45 cm depth. Holford (1997) reported that slow mobility of P in many agricultural soils is necessary to ensure plant productivity. The recovery of applied P by crop plants in a growing season is very low, because in the soil more than 80% of the P becomes immobile and unavailable for plant uptake because of adsorption, precipitation, or conversion to the organic form. There was no significant difference in residual soil P between rye (0.02%) and sorghum sudangrass (0.02%); between sorghum-sudangrass (0.02%) and tall fescue (0.02%); and between tall fescue (0.02%), alfalfa (0.02%), Russell bermudagrass (0.01%), and corn (0.01%) (Fig. 5). This suggests that rye and sorghum-sudangrass are less efficient at P removal from the soil compared to the rest

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of the forages in the study. Over half of residual total P under tall fescue, alfalfa, Russell bermudagrass, and corn combined is found under ryegrass and sorghum-sudangrass (Fig. 5). Residual P in 2002 (0.02%) and 2003 (0.02%) were not significantly different (Fig. 6). This is because P does not leach well unless soil is very porous, low in CEC, and low in specific surface area.

V. Conclusion and Recommendations

As soil depthincreased, itwasfoundthat the amount of soil total N and P decreased significantly because P has been shown to be relatively immobile and because of accumulated organic matter from dead roots and other decayed plant parts is greater near the soil surface. The highest annual forage dry matter yield over four replications in 2001 was observed with sorghum-sudangrass (8,000 kg ha-1) and the lowest yield was observed with alfalfa (2,000 kg ha-1). In 2002, the highest forage dry matter yield was observed with Russell bermudagrass (19,000 kg ha-1), and the lowest dry matter yield was observed with corn (4,000 kg ha-1). Finally, in 2003, the highest forage dry matter yield was observed with Russell bermudagrass (13,000 kg ha-1) and the lowest dry matter yield was observed under sorghum-sudangrass (3,000 kg ha-1), alfalfa (3,000 kg ha-1), and rye (5,000 kg ha-1), respectively. Except for corn, which had a poor stand, all the other crops had the highest dry matter yield in the second year of the study.

There was no significant difference in total dry matter yield between sorghum-sudangrass (20, 793 kg ha-1) and tall fescue (23,182 kg ha-1) and between alfalfa (14,448 kg ha-1), corn (12,880 kg ha-1), and rye (11,378 kg ha-1), respectively. In 2001, a significant difference in total N uptakewasfound between sorghum-sudangrass and the other forage crops. This could probably be due to the quick establishment of sorghum-sudangrass than the other forage crops.

There was no significant difference in total P uptake between Russell bermudagrass and sorghum-sudangrass in 2001. There was no significant difference in total P uptake between Russell bermudagrass, sorghum-sudangrass, and tall fescue in 2002. Corn, on the other hand, showed the lowest total P uptake in 2002. The highest total P uptake in 2003 was exhibited by tall fescue (29 kg ha-1), which was significantly different from the rest of the forage crops.For all forage crops except for corn, total P uptake was higher in 2002 than in 2001 and 2003, respectively. This was due to all the crops except corn yielding more forage in 2002 than in 2001 and 2003. Tall fescue was the only crop that maintained a somewhat consistent total P uptake from 2001 to 2003.

There was a decrease in N (54%) between 0-30 cm and 30-45 cm depthsin 2002 and 2003. More Nwasfound in the 0-30 cm depth (0.11%) than in the 30-45 cm depth (0.05%). A reason for this difference in soil N could be that the 0-30 cm depth had much more living and dead-decomposing plant roots than the 30-45 cm depth. This was probably due to the accumulation of foliage on the soil surfacefrom the previous 2-yr followed by the slow mineralization of PL that was applied to the soil surface.

The following are the recommendations suggested by the researchers.

(a) In order to harvest the largestamount of forage crop for livestockconsumption or for someother use, Russel bermudagrassis the best choice forage crop to grow.
(b) To remediate an excessively PL-amendedsoilthrough N uptake, sorghumsudan-grasscould serve as a better forage cropbecauseitquicklyestablishesthanmany forage crops for the samepurpose.
(c) Tall fescue grass is the most suitable forage crop for total P removal from soils amended with excess poultry litter.

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Table 1 : Baseline soil total N (%) and total P (%) as influenced by depth in 2001.

Depth(cm)	N(%)	P(%)
0-20	0.17a	0.03a
20-40	0.14b	0.02b
40-60	0.12c	0.01c
60-80	0.09d	0.008d
80-100	0.08e	0.008d

Means with the same letter are not significantly different at P ≤ 0.05

Table 2 : Total forage N uptake (kg ha-1) over average of all P rates (kg ha-1) from 2001-2003.

	N Uptake (kg ha^{-1})		
	2001	2002	2003
Crop			
RB	62b	274b	153b
SS	106a	82d	20e
T	56b	203c	182a
A	50b	340a	126c
C	-	18e	56de
R	-	45de	79d

N uptake with the same letter are not significantly different at P≤0.05

RB: Russell bermudagrass *SS:* Sorghum-sudangrass *T:* Tall fescue

A: Alfalfa *C:* Corn *R:* Rye

Table 3 : Total forage P uptake (kg ha-1) over average of all P rates (kg ha-1) from 2001-2003.

	P Uptake (kg ha^{-1})		
	2001	2002	2003
Crop			
RB	11a	37a	14b
SS	15a	37a	8bc
T	8b	29a	29a
A	5b	17b	12b
C	-	7c	9bc
R	-	13b	5c

N uptake with the same letter are not significantly different at P≤0.05

RB: Russell bermudagrass *SS:* Sorghum-sudangrass *T:* Tall fescue

A: Alfalfa *C:* Corn *R:* Rye

Table 4 : Analysis of Variance of residual soil total N and P concentrations (%) in 2002 and 2003

Source	N	P
Depth	***	***
Crop	***	***
P Treatment	NS	***
Year	***	NS
Depth*Crop	***	NS
Depth*P Treatment	NS	NS
Depth*Year	*	NS
Crop*P Treatment	*	NS
Crop*Year	***	***
P Treatment*Year	NS	NS
Depth*Crop*P Treatment*Year	*	NS

* and *** Significant at P≤0.05 and 0.001, respectively; NS, not significant.

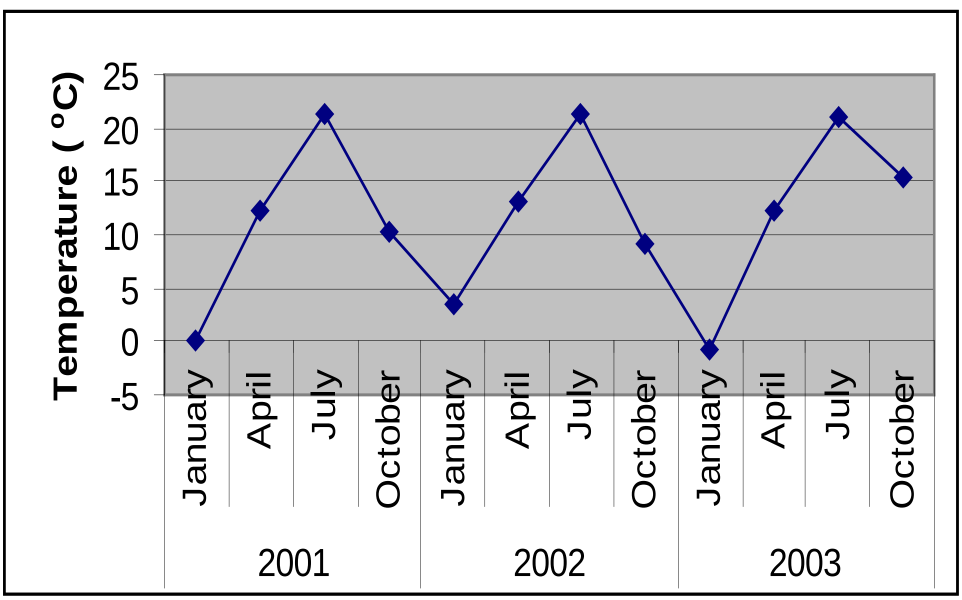

Figure 1 a : Average monthly temperature (oC) at the field study site from 2001-2003.

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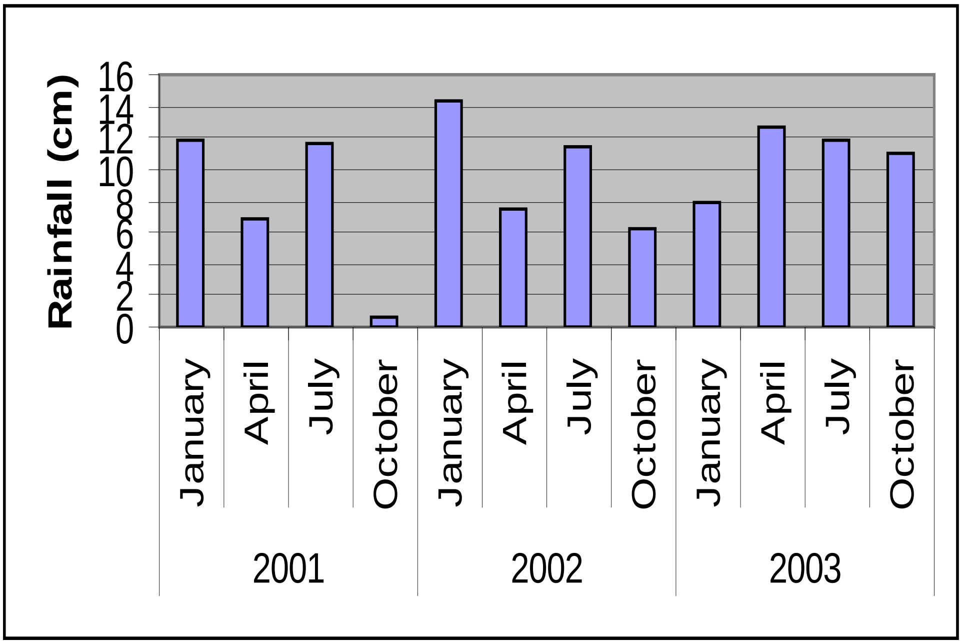

Figure 1 b : Total monthly rainfall (cm) at the field study site from 2001-2003.

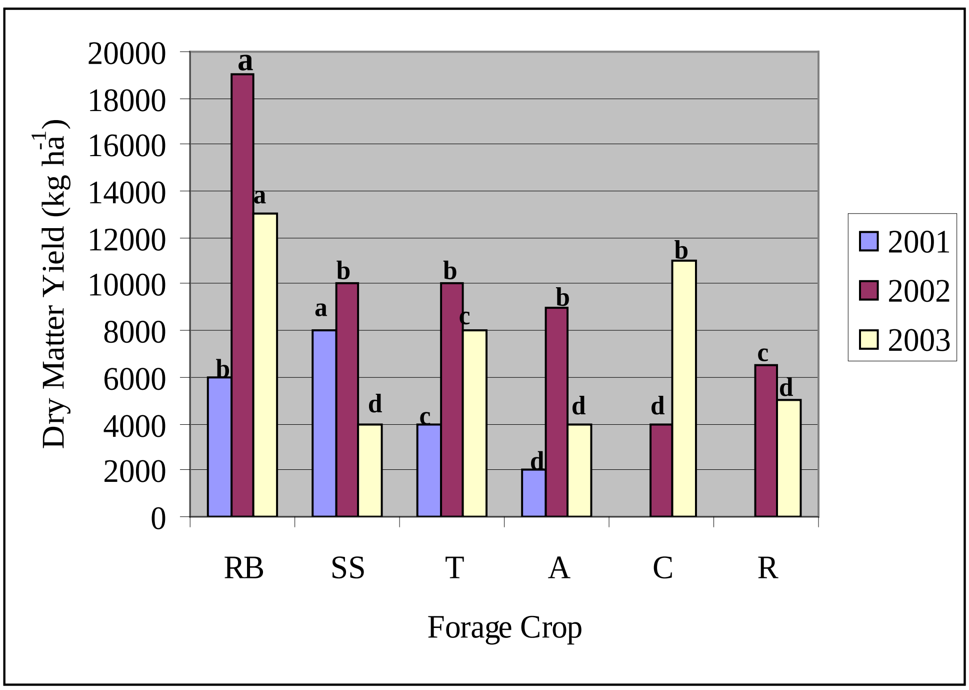

Figure 2 : Total annual forage dry matter yield (kg ha-1) in 3-yr.Means with the same letter are not significantly different at $P \leq 0.05$

R: Rye, *RB:* Russell Bermudagrass, *C:* Corn, *T:* Tall fescue, SS: Sorghum- sudangrass, *A:* Alfalfa

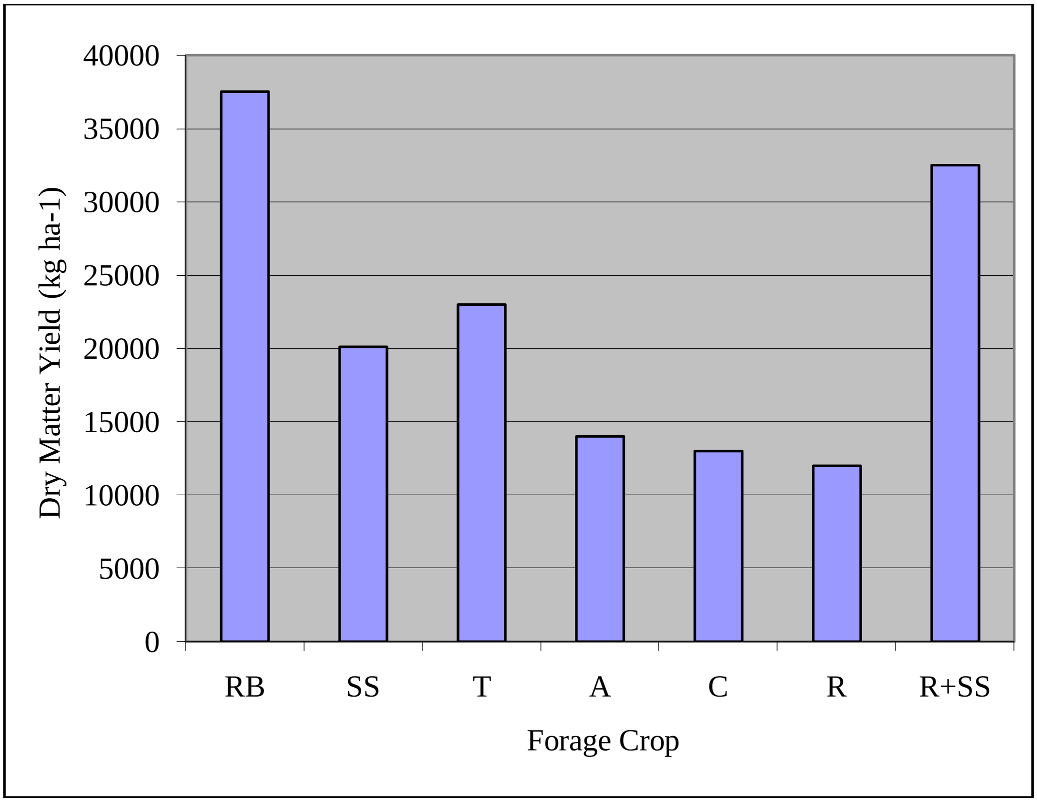

Figure 3 : Total forage dry matter yield (kg ha-1) IN 3-yr. Yields with the same letter are not significantly different at P≤0.05

R: Rye *RB:* Russell bermudagrass *C:* Corn *T:* Tall fescue *SS:* Sorghum-sudangrass *A:* Alfalfa *R+SS:* Rye and sorghum-sudangrass grown on the same plot

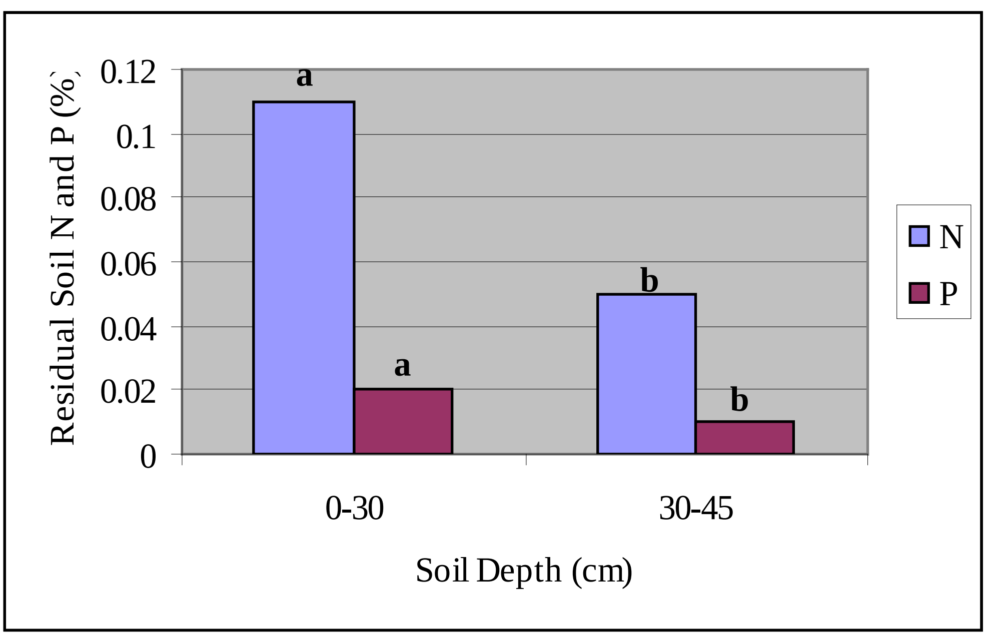

Figure 4 : Residual soil total N and P (%) as influenced by soil depth (cm) in 2002 and 2003.Means with the same letter are not significantly different at P ≤0.05

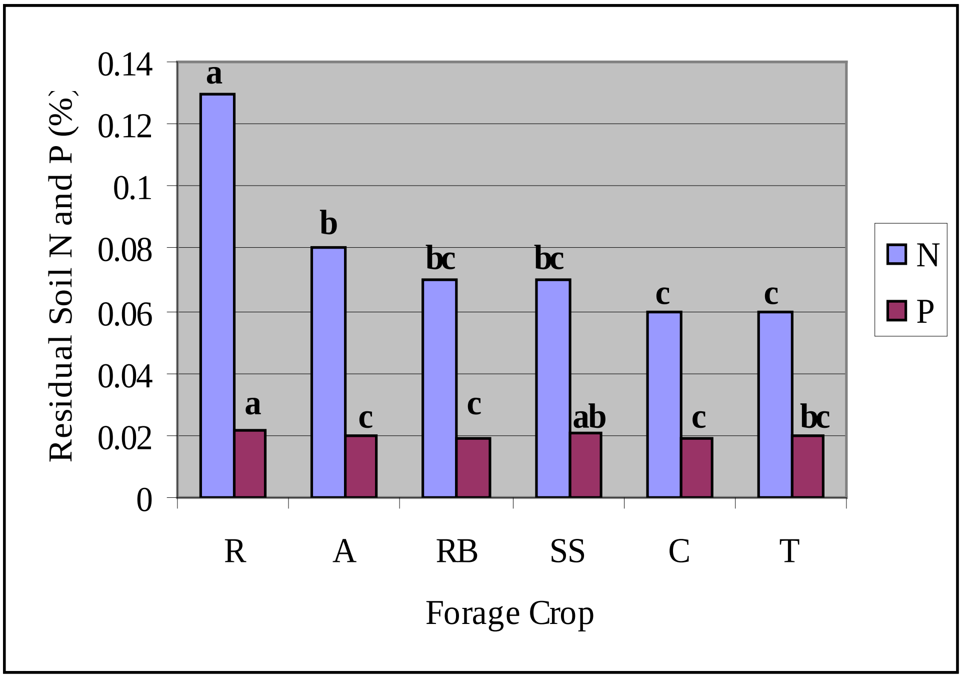

Figure 5 : Residual soil total N and P (%) as influenced by forage crop in 2002 and 2003. Means with the same letter are not significantly different at P≤0.05

R: Rye, *RB:* Russell bermudagrass, *C:* Corn, *T:* Tall fescue, *SS:* Sorghum-sudangrass.

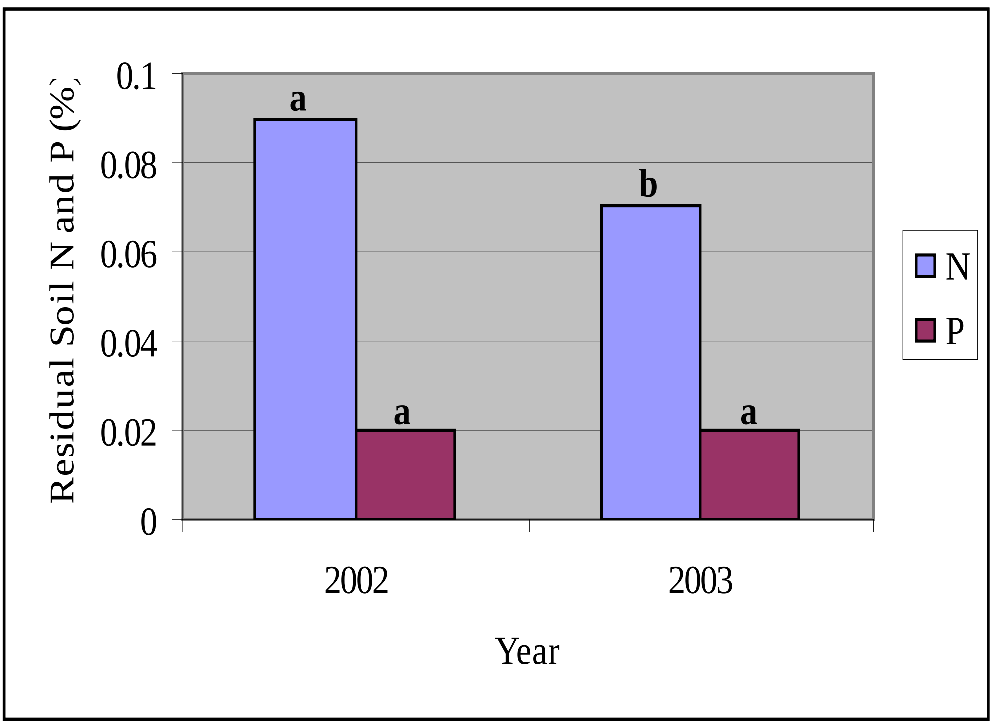

Figure 6 : Residual soil total N and P (%) at 0-30 and 30-45 cm depths as influenced by year. Means with the same letter are not significantly different at P≤0.05

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Towards Systematic Framework for Sustainability

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Abstract- A systematic framework of indicators for sustainability is presented. In our approach there is an emphasis on societal activities that affect nature and on the internal societal resource use. In this way the indicators may give a warning signal to an unsustainable use of resources early in the chain from causes in societal activities to environmental effects. The aim is that socio-ecological indicators shall serve as a tool in planning and decision-making processes at various levels in society. The formulation of the indicators is made with respect to four principles of sustainability, which lead to four complementary sets of indicators.

Keywords: indicators; sustainability.

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Towards Systematic Framework for Sustainability

Dr. N.S. Raman

Abstract- A systematic framework of indicators for sustainability is presented. In our approach there is an emphasis on societal activities that affect nature and on the internal societal resource use. In this way the indicators may give a warning signal to an unsustainable use of resources early in the chain from causes in societal activities to environmental effects. The aim is that socio-ecological indicators shall serve as a tool in planning and decision-making processes at various levels in society. The formulation of the indicators is made with respect to four principles of sustainability, which lead to four complementary sets of indicators.

Keywords: indicators; sustainability.

I. Introduction

The publication of the Brundlandt report 'Our Common Future' (WCED, 1987) and the Rio Declaration (United Nations, 1992a) put the challenge of sustainable development on the agenda for planners, decision makers and politicians at all administrative and institutional levels of the global society. Since then, much effort has been made to define and operationalise the concept of sustainabilily.

Many researchers have suggested various types of non-monetary measures to indicate to what extent environmental slates and functions, material flows, or societal activities can be regarded as sustainable (see, e.g., Vos et al., 1985; Liverman el al., 1988; Kuik and Verbruggen, 1991; Opschoor and Reijnders, 1991; Holmberg and Karlsson, 1992; Adriaanse, 1993; Alfsen and Saeb0, 1993; Bergstrom, 1993; Gilbert and Feenstra, 1994; Moffatt, 1994; OECD, 1994). Most sets of indicators developed so far have focused on the state of the environment rather than on the relation between society and ecosystems. In the present paper we formulate indicators based on four socio-ecological principles for sustainability (Holmberg et al., 1996). The principlesand, hence, the indicators focus early in the causal chain—i.e., in the chain of causes in society to effects in the environment. In this way socio-ecological indicators may give an earlier warning than would environmental quality indicators.

There are two aspects that are important in the construction of our indicators:

(i) There are in many cases long time delays between a specific activity and the corresponding environmental damage. This means that indicators based on the environmental state may give a warning too late, and in many cases only indicate whether past societal activities were sustainable or not.

(ii) The complexity of the ecosystems makes it impossible to predict all possible effects of a certain societal activity. Some damages are well-known, but others have not yet been identified. Most of the sustainability indicators suggested so far are formulated with respect to known effects in the environment. We suggest that indicators of sustainability should be formulated with respect to general principles or conditions of sustainability.

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The socio-ecological principles that form the basis of the socio-ecological indicators focus on the societal activities and interactions with nature and internal societal resource use. The first principle deals with societal use of elements from the lithosphere. The second principle deals with the necessary restrictions on emissions of anthropogenically produced substances. The third principle concerns the anthropogenic manipulation of nature. Finally, the fourth principle deals with the efficiency of the societal resource use. These principles have in common that they are formulated in terms of societal activities.

We use these four principles as a systematic framework for developing indicators. Our aim is then to define indicators that are based on data that reflect societal activities rather than the slate of the environment. In the present paper we exemplify the four different types of indicators by calculating their values using mainly global data.

In Section 2, we discuss various approaches that have been made to indicate sustainability. In Section 3, the four socio-ecological principles for sustainability are reviewed. Then, in Section 4, we develop a set of indicators for each of the four principles. Numerical estimates of these indicators are also presented. Section 5 is devoted to a discussion of the results and on areas for future research.

II. Indicators for Sustainability

There are both monetary and physical approaches lo indicating sustainability. In this paper we focus on physical indicators. Such indicators can be divided into three (main) groups: (i) societal activity indicators (that indicate activities occurring within

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society—the use of extracted minerals, the production of toxic chemicals, recycling of material), (ii) environmental pressure indicators (that indicate human activities that will directly influence the state of the environment—e.g., emission rates of toxic substances) and (iii) indicators of the state of the environment or environmental quality indicators (that indicate the state of the environment—e.g., the concentration of heavy metals in soils and pH levels in lakes).

It should be noted that most indicators for sustainability developed and used so far belong either to the group of environmental pressure indicators or to me state of the environment indicators. This is shown in Table 1 where we have illustrated where some authors have put their focus when developing and evaluating indicators for sustainability.

III. Principles of Sustainability

In our formulation of indicators for sustainability we use a framework of principles that should be fulfilled in a sustainable society (see Holmberg et al., 1996). The principles are presented below.

Table 1 : The focus of some indicators for sustainability

Reference	Indicated area	Societal activities	Environmental pressure	State of the environment
Adriaanse (1993)	The Netherlands	x	x	
Alfsen and Saebo(1993)	Norway			x
Ayres(l995)	Mainly USA	x	x	
ten Brink (1991)	Specific ecosystem			x
Brown etal. (1994)	The world	x	(x)	(x)
Carison(1994)	Sweden	x	x	
ECE (1985)	ECE member countries	(x)	x	x
Environment Canada (1991)	Canada		x	x
Gilbert and Feenstra(1994)	Specific ecosystem		(x)	x
Holdren(l990)	The world		x	(x)
Holmberg and Karlsson (1992)	Not specific	x	x	
Milj0minisleriet (1991)	Denmark.	(x)	x	x
Nilsson and Bergstorm (1995)	Municipality and company	x	x	x
OECD (1994)	OECD countries	(x)	x	(x)
Opschoor and Reijnders (1991)	Not specific		x	x
SNV (1994)	Sweden			x
Haesetal. (1991)	Specific ecosystem			x
Vos etal. (1985)	The Netherlands		x	x
This paper	The world	x	x	

The symbol 'x' indicates the main focus of the work, while (x) means that such indicators are included, but only play a minor role in the work.

a) *Principle 1: substances extracted from the lithosphere must not systematically accumulate in the ecosphere.*

Elements from the lithosphere must not be spread at a rate which will give rise to a systematic increase in the ecosphere. Such an increase will occur if the sum of the anthropogenic emissions and the natural flows from the lithosphere to the ecosphere (weathering processes and volcanic eruptions) exceeds the sedimentation rate and the rate of final disposal in the lithosphere. Because of the complexity and delay mechanisms of processes in the ecosphere, it is extremely hard to say what level of accumulation will cause an effect. In fact, every substance has a limit (often unknown), above which damage occurs in the ecosphere. Increasing amounts of carbon dioxide in the atmosphere, of sulphur dioxide leading to acid rain, of phosphorus in lakes and of heavy metals in soils and in our bodies are all examples of such accumulation. In practice, this principle implies restrictions on the extraction rate of metals and fossil fuels in combination with increased recycling of material and decreased dissipative use of scarce elements. It also implies substitution of abundant elements for scarce elements.

b) *Principle 2: society-produced substances must not systematically accumulate in the ecosphere.*

In the technosphere, molecules and atomic nuclei of different kinds are produced, some of them long-lived, in amounts previously unknown to the ecosphere. If they are emitted faster than they are degraded into molecules or nuclides that can be integrated in the ecospheric cycles, and/or faster than they are removed to the lithosphere, such substances will accumulate in the ecosphere. In order to reduce the amount emitted, one can degrade substances within the technosphere or deposit them in final disposals. CFC molecules destroying the ozone layer, increasing amounts of DOT and PCB in biota, and radioactive inert gases in the atmosphere are all examples of such accumulation. The principle also implies that persistence is a very important aspect of substances that are foreign to nature, and therefore there should be strong restrictions on the use of persistent substances foreign to nature.

Finally, we notethat higher concentrations in the ecosphere may lead to increased sedimentation rates (for Principles 1 and 2) and/or higher degradation rates (for Principle 2) so that a new equilibrium concentration may be established.

c) *Principle 3: the physical conditions for production and diversity within the ecosphere must not become systematically deteriorated.*

A sustainable society must not systematically reduce the physical conditions for the long-term production capacity in the ecosphere or the diversity of the biosphere. Society must neither take more resources from the ecosphere than are regenerated nor systematically reduce natural productivity or diversity by manipulating natural systems. Deforestation, soil erosion, land degradation with desertification as an extreme form, extinction of species of plants or animals, exploitation of productive land for asphalt roads and refuse dumps, and destruction of freshwater supplies are examples of such reduction.

Society is dependent on the long-term functions of the ecosystems. Even if Principle I and Principle 2 are fulfilled, society must be careful with its manipulation of the resource base in order to avoid a loss of the productive capacity for the supply of food, raw materials and fuel. This dependence will become more obvious when the use of fossil fuels is reduced (in accordance with Principle I).

d) *Principle 4: the use of resources must be efficient and just with respect to meeting human needs.*

Principles 1, 2 and 3 constitute the external conditions for a sustainable metabolism of a society. The assimilative capacity as well as the available resource flows are limited. In order to fulfill human needs for a growing global population, the resources and services obtained from nature must be used efficiently within the society. Socially, efficiency means that resources should be used where they are needed most. This also leads to the requirement of a just distribution of resources among human societies and human beings.

IV. Indicator Frameworks for Sustainability Evaluation

a) *Background to sustainability indicators*

The main thrust for sustainability indicators for renewable natural resource management and in agriculture and rural development in particular has its origins in the sustainable development paradigm. The widespread "adoption" or pursuit of sustainable development, and indicators of sustainability, took off following the Earth Summit in Rio in 1992. Agenda 21 called for the development of, amongst many things, sustainable agriculture and land management as well as the systems necessary to monitor their achievement. This has led to a wide range of activities which have sought to define sustainability and, of particular relevance to sustainable agriculture, land management and forestry (Pretty, 1995 for comments on the number of different definitions since the Brundtland Commission (WCED, 1987)). FAO have developed 40 methodology sheets on how to calculate indicators in the areas of agriculture, biological diversity, desertification, fisheries, forestry, freshwater, land use, and mountain ecosystems. Basher (1996) states that currently there isno general agreement on appropriate indicators and many countries are in the process of establishing environmental monitoring networks and testing potential environmental indicators (e.g. Kerr, 1990; Messer etal., 1991; Hamblin, 1992; Doran etal., 1994).

Most, if not all, of these initiatives have been technically led, and have tended to focus on a natural science view of sustainability and associated issues. The Framework for the Evaluation of Sustainable Land Management (FESLM, Smyth and Dumanski, 1993) has, for example, been developed from a technical land management or soil science starting point. Alternative approaches have focussed on community indicators identified through participatory approaches. These have included the International Institute for Sustainable Development, USD, programme on Community Adaptation and Sustainable Livelihoods, CASL, in sub-Saharan Africa, and an IIED project in Brazil on participatory monitoring and output assessment of sustainable agriculture (Sidersky and Guijt, 1997). In relation to desertification, a workshop was held on the grassroots identification of sustainability indicators as early as 1992 (Hambly and OnwengAngura, 1995).

The paper focuses on some of the most relevant issues with respect to development of indicators of sustainable systems. After a very brief explanation of indicators and thresholds, issues of time and scale are highlighted, different frameworks for organising indicator work are discussed and the different dimensions ofAagricultural sustainability commonly identified are outlined.

b) *Indicators and Thresholds*

Smyth and Dumanski (1993) define indicators as "environmental attributes that measure or reflect environmental status or condition of change", Glen and Pannell (1998) argue that "an indicator is a quantitative measure against which some aspect or aspects of policy performance or management strategy can be

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assessed". This criterion of quantification assigned by many authors is not universally accepted, sincesome authors regard qualitative indicators (e.g. visual assessment of soil erosion) as valid tools.

Definitions are numerous, and it is perhaps more useful to identify the uses and desirable properties of indicators. Following Tunstall (1992, 1994), Gallopin (1997) identifies major functions of indicators as:

- to assess conditions and changes;
- to compare across place and situations;
- to assess conditions and trends in relation to goals and targets;
- to provide early warning information; and,
- to anticipate future conditions and trends

A developing issue highlighted by several authors including Syersetai(1995) and Coughlan (1996) is the importance of defining thresholds for indicators. A threshold is a boundary level of a variable which is regarded on the basis of expertise to represent the point at which significant changes occur. "Thresholds are particularly important in an agri-environmental context given the propensity of ecological systems to 'flip' from one state to another" (Moxey, 1998: 14).

When an indicator passes this level then the system is considered to be unsustainable or on the road to unsustainability. Issues arise as to the identification of a threshold level (be it qualitative or quantitative), whether passing a threshold level for one indicator is sufficient to signify unsustainability, or whether several indicators need to have passed their threshold levels before the system is unsustainable.

c) Issues of Scale

The type of indicators constructed in any study will be influenced by the level at which the system is analysed. Indicators in studies such as this may be constructed at the plot, farm, village or community, district, catchment, region, agro-ecological zone (AEZ), or national level. For instance, the individual farmer will often be seeking, or will already have identified, an indicator which forecasts the yield of this year's crop based on a field or farm plot scale. Again at the farm level, the depth of soil may be a key indicator in assessing the sustainability, but at the national level it is impractical to measure the depth of all soils when it comes to assessing the agricultural systems at the national scale. Alternative or broader indicators are needed to achieve this. However, there has to be a link between the different levels. If we are using indicators to assess the relative sustainability of different farming systems we need to be able to relate this information and analysis to assessments at a "higher" level.

The decision about the level at which to collect information and apply indicators depends on both the issues being addressed and the data available. However as one moves up through the levels it may become more difficult to identify causal relationships, to identify desirable outcomes and to isolate choices that can be made with confidence. The level at which, indicators are constructed has implications for the type of indicators that it is feasible to construct. Gomez el al. (1996) argue that working at the farm-level means that social issues cannot be incorporated, whilst Muller (1996,1998) excludes social issues at the plot level but includes them at the farm household level.

There is no prescription here regarding what is the appropriate level of measurement of indicators for this study. The project's emphasis on the investment decisions of farm households of differing scales and success indicate that the farm/farm household are likely to be the focus of attention, but probably not to the exclusion of assessment at the plot as well as higher levels of scale (village, region). The different types of indicator are likely to occur at different levels of scale. However, we expect, the measurement of certain types of indicator (see, for example, driving force or pressure indicators - section 3.6.2) to take place at levels above that of the farm household. So driving forces and pressures in the region (population change, increasing competition for land etc.) will shape the livelihood strategies of individual households.

This issue of scale should be borne in mind throughout the development of this study's indicator sets.

d) Internal and External Indicators

A central issue of the research is the identification of suitable indicators. A key question behind this is who identifies the indicators and on what basis. It is useful to identify two sets of indicators: those identified by "external" experts, such as the project researchers; and, those "internally" identified by the different stakeholders in the systems themselves. The latter group would include farmers, households, communities, and local agencies (e.g. District office of Dept of Agriculture, or NGOs). When considering this division between the role of "external" researchers and local "community" members, it is worth noting that there is also a separation here between issues and indicators. A key issue in the success or otherwise of a system (for example, the maintenance of soil fertility) may be agreed upon by both researchers and community members. However the indicator which each group uses to monitor the issue may differ. Alternatively, it may be the case that the key criteria on which the success or failure of the system is judged differs between researchers and community members, in this case the both the key issues identified (and the associated indicators) are likely to be different.

e) Cross-section or Time-Series Analysis (Stale or Rate)

A major issue to be decided upon here is whether indicators are to be constructed and monitored between sites at a single point in time, monitored over time, or both. Ideally indicators of both types will be measured.

Given the nature of this project, with its focus on the issue of farm size for example, the comparison between different sites is central.

A fundamental issue is time. We want to know what has and is changing. What has happened to the biophysical environment, how have people's perceptions and management and livelihood strategies changed, how have policies and institutions changed and how have these affected each other? However, monitoring over time is more problematic, as information from external sources is generally required.

If trends over time are to be determined then there are two relevant alternative sources of information:

1. Historical sources which may include:
   - Secondary historical information - past records; studies and surveys.
   - Community and individual recollection.
2. Biophysical information from sites which were previously of a similar type to other study sites, but have been cultivated or otherwise used in a different manner over a recent, known time-period. In this way measurements taken at the same moment in time can be treated as observations at differing time points. In this way, a baseline site can be paired with other sites.

f) Indicator Frameworks

Several sets of methodological frameworks or guidelines have been identified for the measurement of sustainability indicators at the farm or community to district levels. These have all tended to come from an approach focussed on sustainable agriculture and/or sustainable land management - often directly related to the FESLM. These have included: the guidelines for conducting case studies under the FESLM (Dumanski, 1995); Protocol for conducting case studies under the FESLM (Bechstedt and Renaud, 1996); and Guidelines for Impact Monitoring (CDE). Other relevant frameworks are those on sustainable livelihoods and poverty assessments. For example, UNDP is also developing a framework for poverty assessment and associated indicators (UNDP, 1999).

The United Nations, World Bank, OECD, European Environment Agency (EEA), IBSRAM and many other organisations and national governments are currently producing indicators or proposed indicators of sustainable development and sustainable agriculture. The frameworks within which these methodologies and indicators are being proposed differ. Some are developments of previous frameworks, but their frequent use is a recognition that a conceptual framework is required to organise indicators.

In addition to the various frameworks used, there are differing dimensions, aspects or properties of sustainable agricultural systems that are proposed as criteria for sustainability assessment.

Pressure-State-Response Framework

The PSR framework, illustrated in Figure 1 and Figure 2 was developed from the stress-response framework which was applied by Friend and Rapport (1979) to ecosystems. This framework is used by OECD, SCOPE (Scientific Committee on Problems of the Environment) and some other organisations working in the field. The PSR framework is the most widely accepted of the many frameworks advocated (Jesinghaus, 1998). Having been adopted by the OECD for its State of the Environment (SoE) group, the European Commission's indicator development also uses the PSR approach. The PSR framework is also used in the methodology of theWorld Bank's Land Quality Indicator (LQI) programme which makes use of the 5 Pillars of Sustainable Land Management (discussed below).

Pressure refers to "human activities that exert a pressure on the environment and change its quality and the quality and quantity of natural resources (the 'state'). Society responds to the changes through environmental, general economic and sectoral policies (the 'response'). The latter forms a feedback loop to pressures." (Gallopin, 1997: 22). These pressures are considered to be negative. An illustration of how the PSR framework might be applied to this study is given in Figure 2.

The OECD acknowledges that the PSR framework has an implicit notion of causality within it since it "tends to suggest linear relationships in the human activity-environment interaction" (OECD: 1993: 5). Unhappiness with this idea that (negative) pressure causes changes in the environment which prompts society's responses is one of the motivations for the development of the driving force-state-response (DSR) framework now discussed.

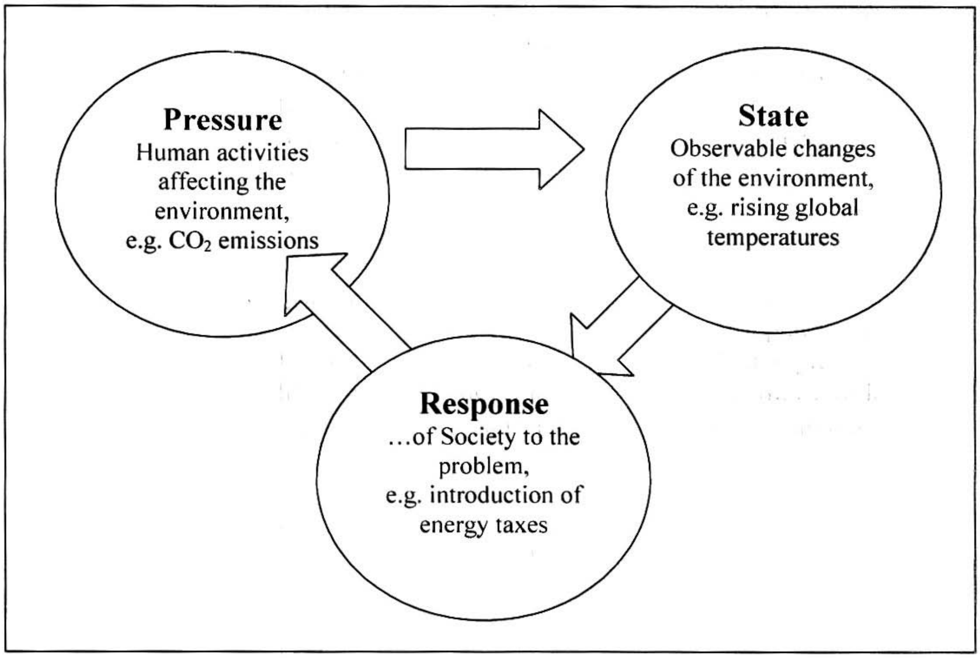

Figure 1 : The PSR Framework

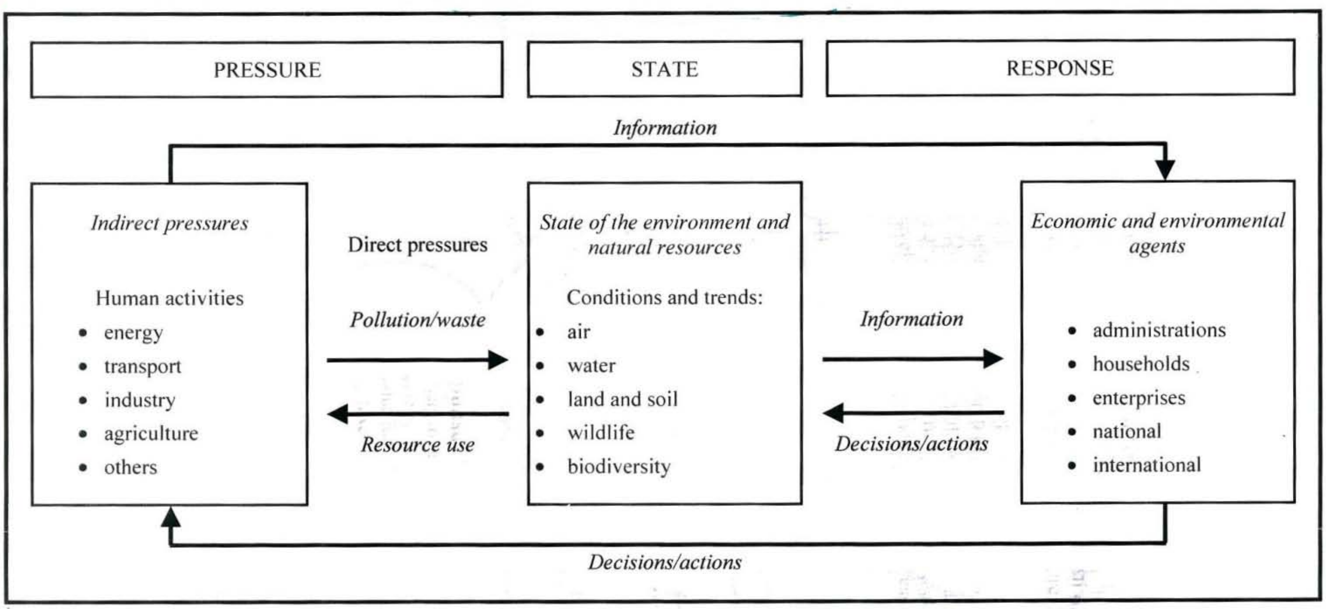

Figure 2 : Pressure - State - Response (PSR) Model

Introducing Driving Forces and Impacts into the PSR Framework

Some organisations prefer variants of the PSR model; for example, the UN Commission for Sustainable Development (UNCSD) bases its indicator set on the Driving force-State-Response model (DSR) model, which allows for a better inclusion of non-environmental variables. The replacement of the term "pressure" in the PSR framework by the term "driving force" was motivated by the desire to include economic, social and institutional aspects of sustainable development.

This adjustment was deemed necessary when one shifts from a consideration of environmental indicators to these indicators plus the state of the human subsystem. (Gallopin, 1997: 22). The extension of the focus to all aspects of sustainable development (social, economic, environmental and institutional) is argued to be "particularly important for developing countriesfor whom an equal balance between the developmental and environmental aspects of sustainable development is important in order to ensure future sustainable growth patterns" (1997: 49).

Another aspect of the DSR framework which separates it from its predecessor is that there is no assumption of causality between indicators in each of the categories."The term 'driving force' indicates...an impact on sustainable development. This impact can be both positive and negative, which is not the case for the pressure category used by the OECD". (Mortensen, 1997: 48-49)."Driving force indicators represent human activities, processes and patterns that have an impact on sustainable development" (Mortensen, 1997: 47).The World Bank has also adopted the DSR framework in its work on indicators of environmentally sustainable development (Pieriet al., 1995), and this has been repeated by other organisations and nations. For a better description of underlying economic trends, some authors have formulated the Driving force-Pressure-State-Impact-Response model, which includes PSR and DSR as special cases (Jesinghaus, 1998).

In the DPSIR frame work State and Impact indicators are separated. State indicators show the current condition of the environment. Examples include the concentration of lead in urban areas; the noise levels near main roads; the global mean temperature. Impact indicators describe the ultimate effects of changes of state. Examples include the percentage of children suffering from lead-induced health problems; the mortality due to noise-induced heart attacks; the number of people starving due to climate-change induced crop losses.

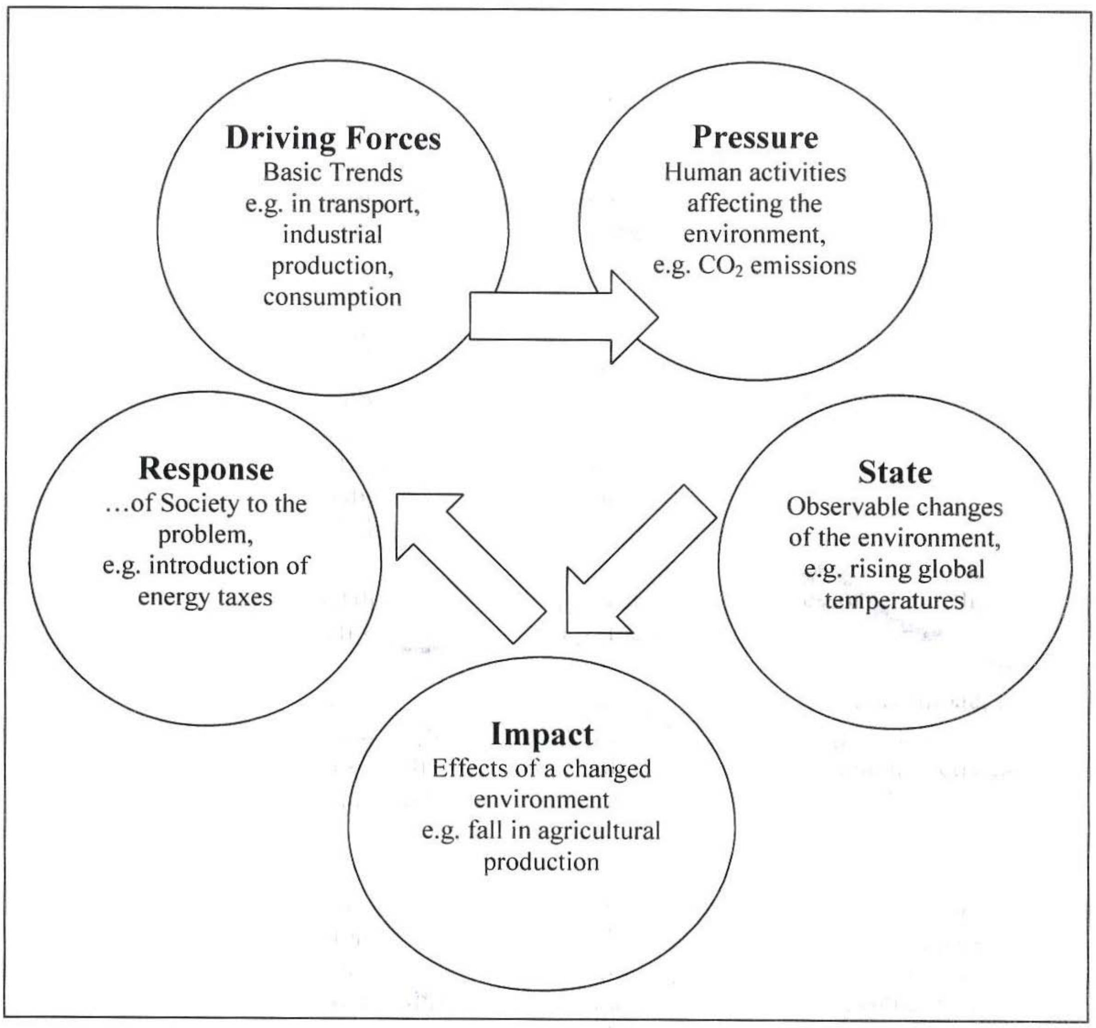

Figure 3 : The DPSIR Framework

V. Currently Used Indicators

a) Gross Domestic Product (GDP)

Gross Domestic Product (GDP) is the market value of all final goods and services produced within a country in a given time period, usually one year. It is usually correlated with the standard of living, which in fact is not true in its entirety. GDP is the basic measure of a country's overall economic output.

b) Determination of GDP

GDP can be determined in three ways. They are the product (or output) approach, the income approach, and the expenditure approach. The 'product approach' sums the outputs of every class of enterprise to arrive at the total. It is used to calculate the market value of goods and services produced in the country. The 'income approach' method measures GDP by adding incomes that firms pay households for the factors of production they hire- wages for labor, interest for capita!, rent for land and profit for entrepreneurship. The last approach to GDP is the 'expenditure approach', which calculates GDP by summing the four possible types of expenditures as follows[1]:

GDP =Consumption + Investment + Government Expenditure + Net exports2

c) Components of GDP

GDP (Y) is the sum of Consumption (C), investment (I), Government Spending (G) and Net Exports (X - M). This is represented in the equation below:

$$GDP(Y) = C + I + G + (X-M)$$

- *Consumption (C):* it's normally the largest GDP component in the economy, consisting of private (household final consumption expenditure) in the economy. These expenditures fall under one of these categories: durable goods, non-durable goods, and services. E.g. includes rent, food, gasoline, and medical expenses.
- *Investments (I):* Includes business investment in equipment and does not include exchanges of existing assets. E.g. includes the purchase of a software or machinery for a factory. Spending on new houses by households is also included in Investment. However, investment in GDP does not mean purchases of financial products.
- *Government (G):* is the sum of government expenditures on final goods and services. It includes salaries ofpublic servants, purchases of weapons for the military, and any investment expenditure by a government. It does not include any transfer payments, such as social security or unemployment benefits.
- *NET EXPORT (X - M):* Net exports represent gross export minus gross imports. Exports include goods and services produced for other nation's consumption, and therefore exports are added. Imports on the other hand include goods and services produced by other nations and brought into the country and therefore imports are subtracted.

d) Three Limitations of GDP

1. GDP only counts goods and services that pass through the market; Production that is not bought or sold does not generally get counted. For example, if a nomadic or agricultural society is self-sufficient within small groups, there may be considerable production unrecorded in the GDP because none of it reaches the market. This omission also means that a rapid rise in GDP may not reflect more production, but a shift from a non-marketed form to a marketed form.
2. GDP has serious deficiencies as a measure of economic welfare: In the late 1960s several economists decided to adjust GDP (actually GNP, which was the measure then) to obtain a better measure of economic welfare, which they called Measure of Economic Welfare, or MEW. They noted that leisure was valuable, but this value was not recorded in GDP. If people work 60-hour weeks rather than 40-hour weeks, GDP will be higher, but people may be worse off. They also noted that many "bads" are included in OOP-higher crime rates lead to more expenditure on police, international tensions lead to more expenditure on arms, more disease leads to more medical spending. etc.and thus GDP overstates welfare. Further, the production of some goods also brings with it some "bads"pollution is an example.
3. Shadow Economy is not reported in the GDP: The shadow economy, the economic activity unreported to the government, is not accounted for in the GDP. For example when a waitress takes tips that she does not report, or a plumber offers to work for less if paid in cash rather than by cheque or a farmer who sells vegetables at a roadside stand understates his revenues to the IRS, each is part of the shadow economy.
4. Gross Domestic Product still is a widely used index and it the value of everything a country has produced in a period of one year. It is also often used to compare the economic activity of two countries. The change in the gross domestic product is often used to describe the development of a country. GDP is used for the samereason other indicators are used:
   1) To Raise awareness and understanding
   2) To Inform decision-making
   3) To Measure progress towards established goals
5. However, when the environmental issues are contemplated, GDP does not fulfill the aims of an index, as it does not inform the decision-makers of the environmental impact that the GDP has had.

e) Carbon Footprints

According to the website Carbon Footprint™ a carbon footprint is a measure of the impact our activities have on the environment, and in particular climate change. It measures the amount of greenhouse gases produced in people's everyday lives concerning, for example, burning fossil fuels for electricity, heating, and transportation. It is also stated in the website that carbon footprint consists of two parts: primary and secondary. The primary footprint is further explained to be a measure of our direct emissions of CO_2 that we can control. These include, for example, domestic energy consumption and transportation. The secondary footprint is stated to be the measure of our indirect emissions from the whole life-cycle of the products we use. Thus, these include all the emissions caused by the manufacturing of the products, and also the waist that they create when breaking down. All in all, the more we buy, the more emissions we cause.[3]

The measurement of carbon footprint is not simple. Wedmann and Minx state that most articles deal with the question of how much carbon dioxide emissions can be allocated to a certain product, company or organization, although none of them provides an unambiguous definition of the term carbon footprint. However, the term is most usually used as a synonym for emissions of carbon dioxide or green house gases expressed in CO_2 equivalents.5

f) Ecological Footprint

At the moment people in the world consume so much that we have already exceeded the Earth's ecological potential. In other words, we consume faster that the planet is able to regenerate its resources. Ruzevicius argues that "the growing pressure of ecosystems creates disintegration and distinction of natural habitats, threatens the biological diversity and well-being of humanity"; and the economic and social development in a country should be oriented such way that it doesn't harm the opportunity to satisfy the needs of future generations.

In his article Ruzevicius states that ecological footprint is an indicator that reflects national and global sustainable development. The concept was first created by Mathis Wackernagel and William Rees in 1990. It exists to indicate the effects inhabitants have on their environment and natural resources in a region or a country, i.e. "how much biologically available earth and water resources are consumed and how much of our waste do they absorb". Ruzevicius states that the concept of Ecological Footprint also includes the product's life-cycle analysis. According to him this analysis quantifies product's impact on the environment through its life, including, for example, the energy and material associated with materials extraction, manufacturing, assembly, distribution, use, disposal, and the resulting emissions. For that reason, the carbon footprint discussed above is a part of ecological footprint.

Ecological Footprint is calculated and reported yearly by an international organization called Global Footprint Network. The size of the ecological footprint is determined as follows: "quantity of arable land together with land used for agriculture needed per person or for a group of people in the city who use energy, food, water, transport, waste disposal as well as for people living in buildings with many other needs." The article of Ruzevicius highlights, though, that even though the Ecological Footprint is a good indicator to reflect national and global sustainable development, it is only ah environmental protection index since "it doesn't integrate social and economical indicators that are important while estimating the sustainable development of the country, region or city.

g) Green GDP

The Green GDP is an indicator which was created in China in 2004 by Wen Jiabao premier of China. It replaced the GDP between 2004 and 2006. Its aim is to calculate the GDP of China in taking into account the negative externalities on the environment caused by the economy[5]. Hence, the calculation of the Green GDP is as follows: GDP - Resource and environmental costs.[2]

The advantages:

- It gives us another perspective on GDP, which provides some keys to improve the protection of the environment and deals with the scarcity of resources
- It gives indications to save our future.[6]
- The importance which is given to the environment does not reduce the one of the economic development.[5]
- No preliminary step to calculate it.

The drawbacks:

- How to calculate resources and environmental costs? The consequences of pollution takes several years to appear, so in which year do we must taking them into account.
- Pollution can damage distant areas; nature can improve or worsen the consequences of the pollution.[3]
- China stopped its use because it gave too bad results: With it, the GDP became close to zero.[5] All in all, this new indicator can easily give some useful information on environmental destruction. It also punishes the countries which pollute too much. However, there are still the problem of accounting and the fact that no one would use it because of the bad results it gives. That is why, to be efficient, all the system of values must change to suppress this idea of competition.

h) Human development index (HDI)

The Human Development Index (HDI) has been created in 1990 by the economist AmartyaSen, in order to give information that arenot taken into account in the GDP. Every year, it is calculated by the Program of the United Nations for the development, for 175 countries.[7]

The HDI is the aggregation of three elements: the GDP per capita, the life expectancy and the level of education. Those three components have the same weight in the calculation in order to reduce theinequalities between all the different countries.[9]

Nevertheless, its main drawback is that if one of the component decreases, the increase of another one can balance the loss. Yet, the components are not substitutable. Besides, the HDI is evaluated between 0 and 1 as its elements, so that let to developed countries a very little margin of progress.9Furthermore, this indicator does not take into account any environmental aspects.

i) Happy planet index

The Happy Planet Index shows "the ecological efficiency with which human well-being is delivered around theworld".[10]

It is composed of three parts[11]:

- Life expectancy at birth: it is quite easy to measure (calculation is based on reliable and constantly updated figures: the number of deceases can be obtained on the basis of death certificates, ages, frequencies). It could be an interesting tool to keep.
- Life satisfaction: First, it seems complex and quite subjective to measure. But researchers have found means of quantifying life satisfaction: the size and strength of social networks, relationship status, level of education, presence of disability, material conditions, such as income and employment. It can be useful as long as it is correlated to higher levels of social capital, better climate, richer natural resources, higher life expectancy, andbetter standards of living. Here is a proof that governments may trust it to assess progress (the achievement of human goals): in 2008, the UK Department for Environment, Food and Rural Affairs used it in its set of sustainable development indicators. But you could always add criteria. That is why it might not be the most appropriate tool for our new indicator, at least if we want to have a "transparent" measure.
- Ecological footprint: It can be measured quite easily (measures the amount of land required to provide for all their resource requirements + the amount of vegetated land required to absorb all their CO_2 emissions embodied in the products they consume, which is expressed in global hectares). It includes a notion of sustainability. The European statistical agency Eurostat is considering incorporating the ecological footprint into its sustainable indicator set; the Welsh government has already adopted it as one of five indicators of sustainability. It is also useful for understanding social justice. Improving living standards in poorer countries can only be achieved in parallel with declining resource consumption in richer ones.

Therefore it is a pragmatic indicator, providing information about the way countries manage to achieve sustainability in the whole process of their activities, focusing on the input and the output. The input is represented by the resources from the environment and the output by the human welfare.[12]

However, there are some limits:

- As it focuses on the input and output, it does not really consider the in-between elements (the operations; economic aspects)
- One of its subcomponents (life satisfaction) is quite subjective to calculate, since you can indefinitely add criteria to assess it.

j) Gross National Happiness

The 4th King of Bhutan, HM Jigme Singye Wangchuck, promulgated GNH since the beginning of his reign in 1972. The fact that he said GDP needed to be channeled towards happiness in 1970s and 1980s was quite new. Since then, GNH has attracted attention, and opinion around the world has started to converge on happiness as a collective goal.[13]

The GNH indicators have been designed to include nine core dimensions that are regarded as components of happiness and well-being in Bhutan, and are constructed of indicators which are robust and informative with respect to each of the dimensions. These nine indicators are-[15]

1. *Psychological Well-being:* It includes the following indicators, general psychological distress indicators, emotional. balance indicators, and spiritually indicators.
2. *Time Use:* In the GNH index, time use component is divided into benchmark indicators of sleeping hours and of total working hours,
3. *Culture:* There are a wide range of indicators such as dialect use indicator, traditional sports indicator, community festival indicator, artisan skill indicator, value transmission indicator, and basic precept indicators
4. *Community vitality:* Community indicatorsare family vitality indicator, safety indicator, reciprocity indicator, trust indicator, social support indicator, socialization indicator, and kinship density indicator
5. *Health:* Three main indicators take place within the health measuring, health status indicator (self-rated health, disabilities, body mass index, and number of healthy days per month); health knowledge indicator (HIV transmission and breast feeding practices); barrier to health indicator (distance to the nearest health facility)
6. *Education:* Education attainment indicator as well as knowledge and skills
7. *Environmental Diversity:* GNH also focus on ecological indicators such as Ecological

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degradation indicator, Ecological knowledge indicator, and afforestation indicator.

8. *Living Standard:* The living standards indicator consists of income indicator, housing indicator, food security indicator, and hardship indicator.
9. *Governance:* Government performance indicator, freedom indicator, and institutional trust indicator.

k) GNH Index Construction

In a first step, there is a comparison between the different districts surveyed, to see which districts have higher GNH scores. After that, GNH is analyzed across time to see if GNH is decreasing or increasing after we conduct future surveys.

The next step is to decompose the GNH by dimension (or indicator), by district, by gender, by occupation, by age group etc., in order to see how shortfalls in GNH vary across disaggregated levels. This information reveals immediately in what dimensions of life shortfalls from sufficiency are most acute. Only once the GNH is decomposed, tracking this decomposition across time is the best way to see in which dimensions sufficiency is increasing or decreasing.

The last step is to study the average severity of deprivations, to identify whether the gap below the sufficiency cutoff is deepening or narrowing across time.[15]

Table 2 : Matrix for sustainability indicators

Dimension s(FESLM)	Assets (SRL)				
	Natural	*Physical*	*Financial*	*Human*	*Social*
Productivity	Levels and trends for: Productivity (per unit of land, per unit of water [irrigated systems])		Levels and trends for: Rates of return on investment [financial outlay]	Total earned income (on-farm and off-farm) per working household member	Active cooperative association-ns, organisations; Government extension services; Labour or asset sharing.
Economic viability		Return on fixed capital assets. Access to markets	Farm gross margins Farm profit Net household income	Affordability of health, education	Contributions to / claims on social welfare.
Production risk/ security	Pest/ disease risks. Months with lack of water Flood and fire risk Cultivation of 'marginal' land	(Investment in) flood control and irrigation infrastructure.	Output and input price variability; Savings and debt levels Credit access Income diversity Insurance Welfare/pensions	Health status Educational attainment Unemployment	Security of crop, livestock from theft, damage; Security of land use rights Government food security measures; Gifts, loans in times of need
Protection from degradation	Soil 'quality', Soil erosion Pesticide use and toxicity levels Agro- biodiversity Ground cover (deforestation) Conservation technologies				Environmental; organisations, campaigns; Local natural resource management authorities, organisations
Social acceptability	Conflicts over access to, or tenure of, land, water etc	Distribution of access to infrastructure, equipment	Income distribution within society / 'community' / household	Inequality in access to health / education / training	Accountability of elected or customary representation or leadership Social exclusion.

VI. Socio-Ecologicai Indicators for Sustainability

For each of the socio-ecological principles reviewed in the previous section we define a set of socio-ecological indicators. These indicators are formulated so that they reflect to what extent (a certain aspect of) a societal activity violates the corresponding principle.

a) Indicators for Principle[1]

The basic idea behind the first principle is that the total flow of an element from the lithosphere to the ecosphere — i.e., societal emissions of an element extracted from the lithosphere as well as weathering and volcanic processes, should not exceed the return flow of the same element from the ecosphere to the lithosphere, by sedimentation processes and by flows to final deposits in the lithosphere.

As a starting point for the formulation of indicators for Principle 1, we use Fig. 4, which shows some basic features of the cycle of a specific element between the lithosphere, the technosphere and the ecosphere.

The variables used are XT and XEfor the total contents of the element in the technosphere and the ecosphere, respectively, and XR for the total resources. Furthermore, kex is the annual rate of extraction, kw is the total natural contribution to ecosphere (i.e., weathering and volcanic eruptions), kem represents the emissions of the element from the technosphere and ks is the rate of sedimentation from the ecosphere to the lithosphere. It should be observed that in general ksis an increasing function of the total content in the ecosphere. Society can prevent the accumulation of lithospheric materials in the ecosphere by (i) limiting the extraction rate, (ii) limiting the leakage from the technosphere—i.e., by using high degree of recycling and by avoidingdissipative use, (iii) returning the material to underground repositories (dashed line in Fig. 4) and (iv) increasing the sedimentation rate (e.g., by guiding the emissions from the technosphere to areas in the ecosphere where the sedimentation rate is high).

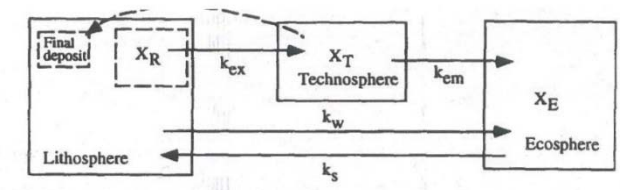

Figure 4 : An element is extracted from the lithosphere and used in the technosphere.

Eventually it will be emitted to the ecosphere. where it will remain until sedimentation processes once again bury it in the lithosphere. The figure shows that the total contents of the element will increase in the ecosphere if the total emissions from the Iechnosphere(kem) plus the natural flow from the lithosphere (kw) exceed the rate of sedimentation (ks). The dashed tine represents direct flows from the technosphere to the lithosphere for final deposition in repositories. At present, this option is only planned for radioactive waste.

There are several reasons for putting the focus early in the causal chain when indicating Principle I. The elements that are extracted do not disappear and as long as we do not have clever strategies for preventing accumulation in the ecosphere, a plausible first approximation is therefore that the elements extracted will eventually leak to the ecosphere. Furthermore, the diffuse emissions from the consumption sector of the economy now exceed the more easily detected emissions from the production sector for many elements. Bergback (1992) has shown that this is the case for many metals used in Sweden. The residential time is often longer in the consumption sector than in the production sector.

b) Socio-ecological indicators based on Principle [2]

According to the second socio-ecological principle for sustainability, substances that are produced in society must not systematically accumulate in the ecosphere. Here, we formulate socio-ecological indicators for substances that are naturally existingand for substances that are foreign to nature.

i. *Indicators for man-made substances that are naturally existing*

The main idea behind the two first principles for a sustainable society is that sustainability requires that human disruption of the natural cycles and flows of substances are small enough to avoid a systematic accumulation.

Table 3 : Indicators for elements extracted from the lithosphere

Element	Cone, in soils (mg/kg)	Weathering [J] and voluanic (kion)	Mining (kum)	Fossil fuels [b](kton)	$I_{1.1}$ [c]	$I_{1.2}$ [d]
			Metals			
Al	72000	1 100000	18000	34000	0.048	0.01
Fe	26000	390000	540000	34000	1.4	1
K	15000	230000	24000	340	0.11	
Mg	9000	140000	3100	690	0.028	0.01
Ti	2900	44000	2500	1700	0.096	0.02
Mn	550	8300	8600	170	1.1	
Zr	230	3500	880	140	0.3	
V	80	1200	32	350	0.32	
Zn	60	910	7300	260	8.3	6.9
Cr	54	830	3800	34	4.6	2.6
Cu	25	380	9000	55	24	23
U	24	360	9.9	220	0.64	
Ni	19	300	880	570	4.8	2
Pb	19	290	3300	85	12	19
Ga	17	260	0.037	24	0.092	
Nb	11	170	14	14	0.17	
U	2.7	41	47	3.4	1.2	
Sr,	1.3	20	210	5.7	11	
Mo	0.97	15	110	17	8.5	4.2
Be	0.92	14	0.34	10	0.76	
Cd	0.35	5.3	20	3.4	3.9	3
Hg	0.09	1.4	5.2	10	6.5	17
&»	0.05	0.75	15	1.7	22	
			Semi-metals			
Si	310000	4700000	4600	95000	0.021	
B	33	500	0.37	250	0.52	

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As	7.2	110	19	18	0.33	
&e	1.2	18	0.27	17	0.96	
Sb	0.66	9.9	54	10	6	
		Non-metals				
C	25000	780000		5400000	6.4	
S	1600	33000	58000	100000	3.7	
F	950	14000	2300	240	0.17	
P	430	6500	21000	1700	3.5	
Se	0.39	5.9	2.1	12	2	

[a] Weathering mobilization is calculated using average concentration in soils (column I) und suspended sediment flux of 1.5 • 1016 g per year in rivers (Nriagu, 1990),

[b]Data for contents of trace elements in crude oil are from USA (Yen. 1975). However, the only elements for which flow associated with crude oil are considerable compared with the flow associated with coal are V, Ni and Hg. The flows of elements associated with fossil fuels predominate over the amount that is mined for several elements: e.g., V, Li,Gu, Be. Hg, Si, B. Ge, S, Se and, of course, for C. Surprisingly, thisis also true for aluminium.

[c]Indicator I1.1 is calculated as anthropogenic flows from the lithosphere to the ecosphere divided by the natural flows. The anthropogenic flows are mining and flows associated with fossil fuels and the natural flow-, are weathering and volcanic processes. Data from 1990.

[d] IndicatorI1.2 is calculated as the accumulated mining since 1900 divided by me amount in thetop soil layer in the human area (see the text). If flows from fossil fuels had been included, the indicator value would increase substantially for a number of elements.

Source: BP Statistical Review, Yen (1975). Valkovic (1983).Nriagu (1989), Sposito (1989). Crowsoti (1992), Speight (1992), Wallgren (1992). Walker and Kastings (1992), Sigenthaler and Sarmiemo< 1993), Holmberg el al. (1996) and Karlsson et al. (1994).

Table 4 : Indicators for Principle [2]

Substance	$I_{2.1}$	$I_{2.2}$
CO_2	0.07	1.8[a,b]
CH_4	1.4 - 4.1	2.7 [b]
$N_2(g) \rightarrow N(active)$	1.3 – 3	--
N_2O	0.5 – 1	1.5 [b]
NH_3 and NH_4^+	0.02 – 0.09	--
NOx	1.9 -2.6	--
SO_2	0.7 – 6	
C^{14}	0.1	1.1

[a]The value for the second indicator for CO; gives the atmospheric concentration in the year 2100 divided by the pre-industrial concentration, given that the present global emissions are kept constant. In order to estimate the long-term atmospheric concentration of CO2, one has to make assumptions about emissions scenarios and fossil fuels reserves. Maier-Reimer and Hasselman (1987) estimate that for a stock of fossil fuels equal to 5000 Gton C, the atmospheric concentration of CO2 would reach peak concentration as high as 4.5-6.4 times the pre-industrial level (all depending on the rate at which the stock of fossil fuels is combusted). No net-sink in biomass is assumed.

[b] Values from IPCC(I995).

Sources: Bolin (1979). Soderlund and Rosswall (1982), IPCC (1990), IPCC (1992). IPCC (1995), Jaffe (1992), Bates et al. (1992), Graedel and Crutzen (1993), UNSCEAR (1993).

Indicators for Principle [3]

The global population is expected to nearly double by the year 2050 (United Nations. 1992b). In order to provide a sustainable supply of biomass for food, material and energy for the growing population, we need to maintain the services of the ecosystems. These services include, for example, generation and maintenance ofsoils, disposal of wastes and cycling of nutrients, pest control and pollination (Ehrlich and Ehrlich, 1992). This means that the productivity of lands and the biodiversity of ecosystems must not worsen. This is the essence of Principle [3].

Human activities threaten ecosystem productivity and biodiversity in two ways. The exchange of substances between society and nature is dealt with by the indicators for Principles 1 and 2. In this section we focus on societal activities that by manipulation or harvesting of ecosystems may threaten sustainability and, in particular, biodiversity and ecosystem productivity.

ii. *Large-scale transformation of lands*

Since the beginning of the 18th century, humanity has carried out a large scale transformation of the Earth's ecosystems and productive surfaces (see Fig. 3). The area used for crops and grass lands has increased dramatically at the expense of huge losses of primary forests. In the long run this trend is obviously not

c) Indicators for Principle 4

Principles 1, 2 and 3 constitute the framework for a sustainable influence on nature. Principle 4 states that if we want a prosperous society within this framework, the societal metabolism must be efficient and just. This principle covers four aspects: overall efficiency, inter- and intragenerationalequity, and basic human needs. Below, indicators for some of these aspects are given:

i. *Indicator no.4.1: overall efficiency*

A simple schematic description of the societal metabolism is given in Fig. 4. The overall efficiency indicators are measures of the productivity in the technosphere. They indicate how much service13 that is delivered for a certain amount of resources extracted from nature, normalized with respect to the situation a certain year y:

$$\boldsymbol{I_{4.1}} = \frac{\frac{\text{Service}}{E}}{\frac{Service_{\,y}}{E_y}}$$

It is also possible to complement the overall efficiency indicators with specific efficiency indicators that focus on the internal conversion in the technosphere— e.g., the flow P per unit of total input E + R, or the recirculation R compared to the total input E + R.

$$\eta_1 = \frac{P}{E+R};\ \eta_2 = \frac{R}{E+R};$$

The recirculation flow *R* can also be compared to the total output *P** + *L:*

$$\eta_3 = \frac{R}{P^* + L}$$

In a stationary state *P* equals *P** and *E* equals *D.* It is possible to normalize the efficiencies with normalization values η_n determined according to various principles: a normalization to the maximum possible theoretical value, to the best available technology (BAT), or to a desirable value. We get complementary efficiency indicators:

$$I_i = \frac{\eta_i}{\eta_n},$$

where $i = 1, 2, 3$. In Table 7 some examples of overall efficiency indicators are shown. We can see, for instance, that the supply of food per hectare of land has increased, whereas the supply of food per phosphate input has decreased since 1970.

Table 5 : Overall efficiency indicators

Efficiency indicators	1970	1980	(1987) 1990
Food			
Calories in food/Phosphate input (World)	1	0.67	(0.61)
Proteins in food/Phosphate input (World)	1	0.66	(0.60)
Fats in food/Phosphate input (World)	1	0.69	(0.67)
Calories in food/ Area input (World)	1	1.03	(1.08)
Proteins in food/ Area input (World)	1	1.01	(1.07)
Fats in food/Area input (World) '	1	1.07	(1.18)
Energy			
GDP/Primary energy input to the World (USD/J)	1	1.07	1.21
GDP/Primary energy input to Sweden (USD/J)	1	1.06	1.12
Dwelling area/Primary energy input to the dwelling sector in Sweden (m^2/J)	1	1.11	1.14
Personal transport/Primary energy input to personal transport in Sweden (Pers. km/J)	1	0.91	0.99
Goods transport/Primary energy input to goods transport in Sweden (ton km/J)	1	1.06	0.93

The values are normalized to the year 1970.

Sources: Bumb (1989), FAO Food Balance Sheet (FAO. 1991). Schipper et al. (1994) and Brown ei al. (1994).

As an example of a complementary specific efficiency indicator we have chosen to indicate the efficiency of the use of nutrients in the Swedish agricultural system. This indicator is defined as;

$$\eta = \frac{\text{Nutrients in provisions from the Swedish agricultural system}}{\text{The supply of nutrients to the Swedish agricultural system}}$$

VII. Epilogue

This paper has set out an analytical framework based on the Sustainable Rural Livelihoods approach, and used this to generate a matrix of potential indicators compatible with five 'dimensions of sustainability' from commonly-used indicator frameworks. In doing this we have sought to bring together disparate components of the 'sustainability' literature into a single methodological approach. In setting out to test the applicability of this approach in assessing the sustainability of farming in East and Southern Africa, we recognise that exclusive reliance on a predetermined set of indicators to be measured at each case study site would be a mistake. Firstly, indicators may vary in their relevance according to the local environment and the final purpose of their measurement and monitoring (and the practicality of this measurement). Secondly, it is important to test externally-defined indicators against local stakeholders' criteria for valid indicators of the success and sustainability of their agricultural systems and livelihoods.

The main emphasis of this paper is the method for developing socio-ecological indicators for sustainability. Such indicators should be (i) based on a framework for sustainability (the four socio-ecological principles for sustainability) and (ii) focus early in the causal chain.

Practical experience from companies and local authorities has shown that the socio-ecological principles that we have used as a systematic framework, function well when making strategic decisions.

There are no exact limits defining sustainability. Instead, the border between sustainability and unsustainability is not sharp. This means that it is not possible to determine exact reference values for sustainability. However, many of the societal activities today are far from sustainable, which means that time series of the indicators would enable us to say whether sustainability is approached or not. However, it would also be a mistake if no "external" framework or set of indicators were to be identified based on prior knowledge and technical expertise. This is important to ensure a basis of comparison between different study sites, to assess the robustness of the methodological approach proposed, and to permit valid policy conclusions. For this, success or sustainability of an agricultural system needs to be assessed from different perspectives: local or farmers' perspectives as well as the scientific or technical. It is therefore useful to start off with a core set of indicators around which a final set will be built using stakeholders' indicators. It follows logically from this that the methodology of identifying indicators will be important. This should deliver:

- locally relevant and easily measurable indicators;
- indicators which represent the potential diversity of perspectives of different users on success and sustainability- from farmers/local communities (both wealthy and poor), through scientists, to policy makers;
- indicators which encompass both agricultural systems and peoples' livelihoods;
- indicators which can be "related" to policy; and,
- the smallest number of indicators possible, to make any assessment of success or sustainability of agricultural systems and livelihoods relevant.

The research steps set out above are, obviously, presented sequentially. The process in reality should be characterised by loops and feedback between the various people involved (most importantly, the various project teams and the inhabitants of the study areas).

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Sustainable Analysis of Small Rivers with a Case Study in Poland

By Czarnecki, A., Ramos-Ribeiro, R.R. & Lewandowska-Czarnecka, A.
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Abstract- The present study represents a methodological research of environment factors and anthropic perturbation related with small rivers in the Vistula Mouth in Poland. The aim of this study is to assess the potential of environment services in one study area with a particular environment characterized by the small rivers. The methodology used is based on field expeditions and review of the literature. In this work it was analysed the concept of rebuild connections' between small rivers and local society. In particular, this work, relates how to achieve an environment with better interaction with local society, it was performed an analysis of possibilities to carry out actions to maintain, preserve or rehabilitate the small rivers. The results of the study shows the importance of the small rivers, as reported in this paper make some recommendations for further interaction between small rivers and local society.

Keywords: *ecosystem services; landscape; climate change; small rivers; ecology; Vistula River.*

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SUSTAINABLE ANALYSIS OF SMALL RIVERS WITH A CASE STUDY IN POLAND

Strictly as per the compliance and regulations of:

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Keywords: ecosystem services; landscape; climate change; small rivers; ecology; Vistula River.

I. Introduction

The link between small rivers is very important for the transport and landforms, is important to understand better these kind of system.

This article presents a literature review and study of case at Vistula Mouth in Poland, for improve the connection of small rivers with local society. The interactions between environment services and social economy are characterized the landscape change in the study area. The issue of urban river revitalisation is complex (REURIS, 2012).

The concept of river renovation involves understand the natural system, looking at the changes that have occurred (JANES et al., 2005).

The study area is the canals of the Vistula River in the North of Poland. The area of the small rivers was characterized before as one efficiently network of canals used most for boat transport of the industry in the region, nowadays this area is characterized by abandoned canals.

II. Methodology

The data used in this study is result of a qualitative investigation at the Vistula delta river, with situations analyzed information about techniques to rebuild connections between canals, carry during the years 2012 and 2013.

It was examined the socio-economic environmental system related with environment services and their social impacts.

This research was conducted under the project `Wody delty Wisly. Natura i kultura´ [Waters of the Vistula delta. Nature and culture], at the Foundation for Development in the University of Gdansk.

III. The Study Area

The Baltic region of northern Poland has several canal systems. In places, these canals utilize natural glacial lakes, rivers and valleys. In this places, the canals cross upland areas in order to connect different drainage basins. The Fig.1 shows the location of the study area in Poland and the Vistula River.

Figure 1: Location of the study area (red circle) on the delta of the Vistula River in Poland.

The Vistula is one of the biggest European rivers and more or less undisturbed between dikes (PASTUSZAK et al., 2012). It is part of an important ecological corridor for animal and plants, connecting southern and North of Central Europe Lowlands. The system with floodgate allows the transport of boats from one level to another.

The study area is influenced by sea currents and plateau, with altitude around 10m above sea level

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(CZARNECKI and LUC, 2001). The environment is unstable due to changing water levels in the Vistula and also because of irregular marine backwaters pushed by stormy wind and flood waters drained moraine plateau.

The Vistula floodplains with its meanders, islands are also a specific habitat for many aquatic and terrestrial species (KEIZERA et al., 2014). One of the reasons for this area be unstable is because of the floods, as result of the low high level of the landscape, with average level 1,5 metres above from the sea. The small rivers are also characterized by minimal decline.

The study area of the delta of the Vistula River is in large part reclaimed artificially by means of dikes, pumps, channels and extensive drainage system. In the past, the water level depended on the state of the Vistula River.

The delta of the Vistula River lost natural features as a result of long-term human interference and during the history became canalized.

The canal in Elblag connects the Vistula estuary with the city of the Ostróda. It starts at the city of Elblag and goes until the southward through the low delta. This canal was constructed under the Old Prussian regime.

The risk of flood at the Vistula Lagoon can reach upstream areas of the Elblag Zulawy and the Great Zulawy, through the river sections such as: Elblag, Nogat, Cieplicówka and Szkarpawa. The main rivers formed from the Vistula are: Leniwka, Nogat and Mierzeja.

The Fig.2 illustrates the small rivers on the study area, the Baltic Sea, the Vistula Lagoon, Vistula River and two main cities in the area: Gdansk and Elbalg.

The presence of drains and canals and other infrastructure enables the development of agriculture and depending on their distance from the sea is a growing field and meadow.

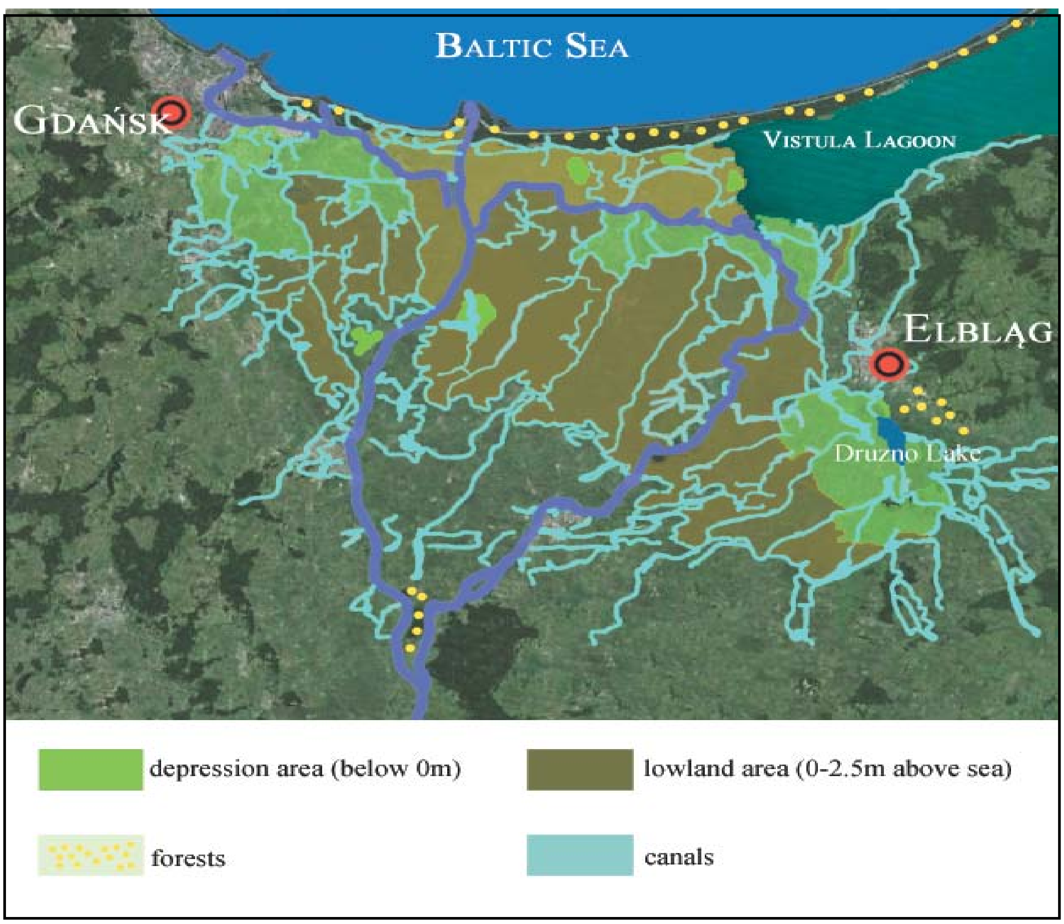

Figure 2 : Illustration of the small rivers and land depression on the study area (Adapt from: CZARNECKI and LUC, 2001).

The flood area around the Vistula Lagoon has an influence of a big area. It can reach not only the polders located alongside of the Lagoon, but also the tributaries. It is of special importance for municipality of Elblag and the Zulawy because the water masses from the Vistula Lagoon can reach Druzno Lake through the Elblag River.

The Fig.3 illustrates the location to the Zulawy region, where the local authorities of the region recognizes the importance of the tourism for the development of the region. In the recent years new yachting marinas were build.

Figure 3 : Delta of the Vistula River and the Zulawy region (yellow circle).

The flood is characteristic of this area with depression. For instance, the downfall over the polder area can result in flooding, that is why the effectiveness of flood protection is important. A flood within polder area can result in long-lasting power cuts. The floods within polders do not represent a great threat to society, they can, however, cause heavy economic losses if they occur in some periods of the year.

IV. LANDSCAPE ANALYSIS

In the 60th and 70th century as result of the intensification of agricultural production, it increased the doses of artificial fertilizers and pesticides, on the small rivers (NERUDA et al., 2012). Some of these inputs is not used by plants and results in eutrophication, as response of the ecosystem fot these substances. The presence of high concentrations of nutrients and lack of shading on the banks by trees, results in a high biological productivity, threatening the small rivers.

Several rivers of Europe including the Vistula, experience floods and risk right waters. The Fig.4 shows on situations with two landscapes changed in two sides: 'a' and 'b,' separated by one dike. The areas are not exposed for the floods are used by agriculture.

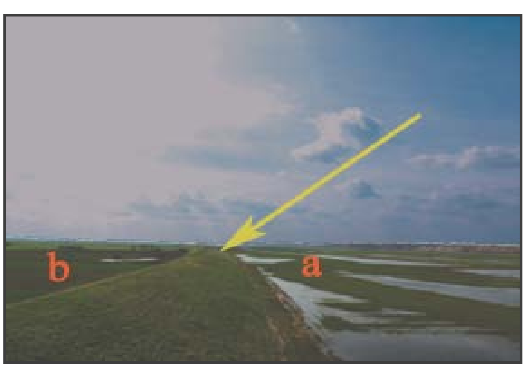

Figure 4 : Two sides of the landscape separated by one dike (yellow set) (Photograph: A. Czarnecki).

Figure 5 : Bigger canal used for transport (Photograph: A. Czarnecki).

With the development of new roads for transport on the study area, the small rivers are no so used for transport. The result is of lack of funds for maintenance of the canals, following by many situations as for example the erosion. However the Vistula delta waterways serves as passage to the Lake District.

The main problem is the inexistence, up to now, of management of the canals of the delta in the Vistula River. So far, this unstable area could be used for environment services and tourism attraction in orden to develop the local economy.

Figure 6 : Sluice system used for navigation at the canal (Photograph: A. Czarnecki).

It had been create systems on the delta of the Vistula River, mainly the lowlands, to protect the area of the cities Gdansk, as result of the importance for the economy, with the purpose to create conditions for develop the area.

Figure 7 : Small river changed by canalization and close remains of companies situated on the border (red set) (Photograph: A. Czarnecki).

Nowadays the study area support many traditional industries, such as shipbuilding, metallurgy and, textile. These new marinas are located for example on Szkarpawa River and Nogat River. The Fig.8 presents one example of renovated waterfront, part naturalized in Poland at the town of Stobrawa on the Brda River.

Figure 8 : Small river in Poland (Photograph: A. Czarnecki).

The area is part of a complex ecosystem. The small rivers and floodplain were converted for a many purposes, including water supply, drainage, transportation, sewage, flood control, recreation, aesthetic values, and lately for the creation of habitats of plants and animals.

Successful completion of the renaturalization projects can increase the attractiveness of the areas and thus attract more users and uses (BOER and BRESSERS, 2011).

V. Conclusions

This paper present aspects of the small rivers on the Vistula Mouth and illustrate the canals. The main condition on the study area is that the canals of the delta of the Vistula River are nowadays relatively abandoned.

A good system of small rivers can become to be tourist attraction needs to be navigated, in order to be another economical source for the small cities on the area.

One new relation with the canals can be used to develop tourism. The positive impact of the tourism includes of economic development of the region. Due to the development, new workplaces should be created. This kind of tourism develops the attention to landscape, ecological awareness and nature preservation.

The Mouth of Vistula is an area rebuilt regarding natural system, with a big area of prevailing wetlands with unstable water level that could be flooded from three sources as drainage of water surplus from 90 meters above sea situated on the Moraine Plateau (GORZEL and KORNIJÓW, 2007). During a regular year, the level of Vistula River water can increases 7 meters.

It is a very clever technical infrastructure, which stabilizes an enlarged area and allows the development of cities industry and agriculture.

It is common that industry in similar condition be replaced by tourism development, where the boating is a key element. The described area it is a clever system maintaining the conditions for the development of biodiversity and providing the possibility of economic development.

For nature protection and development of tourism is need to improve structure and functions of ecosystem. It is important recognise it can be achieved by naturalization of small rivers.

One of the conclusion is the possibility of improve the environment services provided by using the small rivers with a relative small effort compared with the benefits from the results for the society and nature. The system analyzed can to improve the relation between the society and nature. These article describes a connection with small rives and cities, by the history and their natural change.

To achieve an environment with better interaction with local society, it was performed an analysis of possibilities to carry out actions to maintain, preserve or rehabilitate the small rivers. In the past the small rivers were characterized as a useful way for transport with no big environment problems on the area. Nowadays, the small rivers are abandoned and with pollutions as result of the agriculture activity in the zone.

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Appraisal of Existing Sanitation Technology in Nigeria; A Critical Review

By Abogan S.O.
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Abstract- The research was carried out in ten states of the country and the results from the communities revealed the backwardness in the provision of sustainable sanitation technology which indicates the whole Nigeria is still having great problem of sustainable sanitation. There should be serious enlightenment campaign about sustainable sanitation technology within Nigeria, while the provision of water by the government to all communities at considerable and affordable cost should be intensified. There should be re-introduction of Public Health Workers in ascertaining provision of good sanitary technology just as in the 70's. Pre-site and post-site visit by the planners before and after given approval for any building to be constructed in Nigeria generally, (especially when the building is to be used for commercial or residential purposes).

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I. Introduction

According to the World Health Organisation (WHO) "Sanitation generally refers to the provision of facilities and services for the safe disposal of human urine and faeces. Inadequate sanitation is a major cause of disease world-wide and improving sanitation is known to have a significant beneficial impact on health both in households and across communities. The word 'sanitation' also refers to the maintenance of hygienic conditions, through services such as garbage collection and wastewater disposal.

The term 'sanitation' can be applied to a specific aspect, concept, location, or strategy, such as:

1. Basic sanitation refers to the management of human faeces at the household level. This terminology is the indicator used to describe the target of the Millennium Development Goal on sanitation;
2. On-site sanitation is the collection and treatment of waste is done where it is deposited. Examples are the use of pit latrines and septic tanks. Food sanitation refers to the hygienic measures for ensuring food safety; and,
3. Environmental sanitation is the control of environmental factors that form links in disease transmission. Subsets of this category are solid waste management, water and wastewater treatment, industrial waste treatment and noise and pollution control.
4. Ecological sanitation is a concept and an approach of recycling to nature the nutrients from human and animal wastes.

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II. Water, Sanitation and Hygiene Practice in Nigeria

The current population of Nigerians with access to safe drinking water is estimated at 58% while those with access to sanitation facilities was put at 32%. This is a far cry from the MDG Target of 75% and 63% for 2015(See table below:

III. MDG Target: the Journey So Far

	Situation in Nigeria in 2008	MDG 7 target for 2015
Population with access to safe drinking water	58%	75%
Population with access to basic sanitation	32%	63%

Source: NDHS, 2008

Adult females collect drinking water more often than adult males (26 and 21 percent, respectively). Results also show that both male and female children below age 15 are involved in collecting drinking water. Most households (85 percent) do not treat their water; about 10 percent of households use an appropriate method to treat their drinking water. Alum, boiling, straining through cloth, and bleach or chlorine are the most common methods used by households for water treatment (NPC, 2009).

IV. Sanitation

Safe disposal of excreta and hygienic behaviours are essential for the dignity, status and wellbeing of every person, irrespective of whether they are rich or poor, live in rural or urban areas, small towns or cities. The primary direct impact of sanitation and hygiene promotion is on health, and it's impacts; the most significant is probably the prevention of diarrhoeal disease. The primary barriers to the transmission of diarrhoeal and other water-related diseases include both infrastructure (such as household sanitation) and hygiene practices (washing of hands with soap or a local substitute at critical times) (WSSCC and WHO, 2005). It is in the light of this the International Community (of which Nigeria is part), committed itself at the World Summit on Sustainable Development that held in Johannesburg in 2002, to 'halve by 2015 the proportion of people without safe sanitation'.

V. The Status of Sanitation in Nigeria

Unless Nigeria fast tracks, it may not meet the MDG target for sanitation of 63 percent access by 2015. United Nations sources estimate that in the last fifteen years, globally rural sanitation access rates have risen just by 3%, from 33% in 1990 to 36% in 2004, while urban sanitation access has gone from 51% to 53% (WHO/UNICEF, 2006). While these access and progress rates are comparable to sub-Saharan Africa averages, Nigeria's large population means that more people are living without sanitation (72 million in 2004) than in any other country in Africa. And at these progress rates, the MDG target for sanitation will not be met. If Nigeria does not meet the target, neither will Africa as a whole (Federal Ministry of Agriculture and Water Resources).

But more important than targets is the impact of the lack of improved sanitation on Nigerian communities. Poor sanitation causes diarrhoea, and the prevalence rate in Nigeria stands, at 18.8% (include source). This contributes to high child mortality rates due to direct deaths from diarrhoea (diarrhoea is the second largest killer of children in the country, after malaria) Poor sanitation is also a major contributing factor to low education enrolment and achievement rates, malnutrition, lagging economic and social development, and poverty as a whole.

VI. Household Sanitation Facilities

A household is classified as having an improved toilet if the toilet is used only by members of one household (i.e., it is not shared with other households) and if the facility used by the household separates the waste from human contact (WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation, 2004).

Table 8 shows that almost three in ten households in Nigeria (27 percent) use an improved toilet facility (31 percent in urban areas and 25 percent in rural areas), while seven in ten households (73 percent) use non-improved facilities (69 percent in urban areas and 75 percent in rural areas). Among households with improved toilet facilities, flush toilets (pipe sewer system, septic tank, or pit latrine) are mainly found in urban areas and are used by 18 percent of households (4 percent in rural areas). Ventilated improved pit (VIP) latrines are more common in the schools in rural areas (14 percent) than in urban areas (9 percent). Overall, 13 percent of households use VIP latrines. Six percent of households use a pit latrine with a slab (6 percent rural and 5 percent urban). Among households with a non-improved toilet facility, 26 percent use facilities that are shared with other households (44 percent urban and 16 percent rural). Less than 1 percent use a flush toilet (not to sewer/septic tank/pit latrine). Overall, 32 percent of households in Nigeria have no toilet facilities. This problem is more common in rural areas (42 percent) than in urban areas (14 percent).

Sanitation practices

Percentage distribution of household and dejure population by type of toilet/latrine facilities, according to residence, Nigeria 2008

Type Of Toilet/Latrine Facilities	Households			Population		
	Urban	Rural	Total	Urban	Rural	Total
Improved, not shared facilities Total	81.4	24.6	27.0	37.5	28.1	31.2
Flush/Pour flush to Piped Sewer System	5,3	1.0	2.5	5.9	1.0	2.6
Flush/Pour flush to septic tank	10.9	2.8	5.8	11.1	1.9	5.0
Flush/pour flush to pit latrine	1.5	0.6	0.9	2.0	0.6	1.1
Ventilate improved pit (VIP) latrine	9.0	14.4	12.5	11.6	17.2	15.3
Pit latrine with slab	4.6	6.4	5.7	6.8	7.2	7.1
Composting toilet	0.0	0.0	0.0	0.0	0.0	0.0
Non-improved facility Total	68.6	75.4	78.0	62.5	71.9	68.8
Any facility shared with other household	44.2	15.7	25.8	89.8	18.0	21.6
Flush/pour flush not to sewer/septic tank/pit latrine	0.4	0.1	0.2	0.4	0.1	0.2
Fit latrine without slab/open pit	7.8	14.2	11.9	9.2	15.7	18.5
Bucket	0.1	0.1	0.1	0.1	0.0	0.1
Hanging Toilet/hanging latrine	1.7	1.7	1.7	1.2	1.4	1.4

No facility/bush/field	13.5	42.2	32.1	11.8	40.2	30.5
Other	0.5	0.8	0.7	0.4	0.8	0.7
Missing	0.5	0.6	0.6	0.6	0.6	0.5
Total	100.0	100.0	100.0	100.0	100.0	100.0
Number	12,100	21,970	84,070	51,147	100,442	150,589

VII. Situation Evaluation

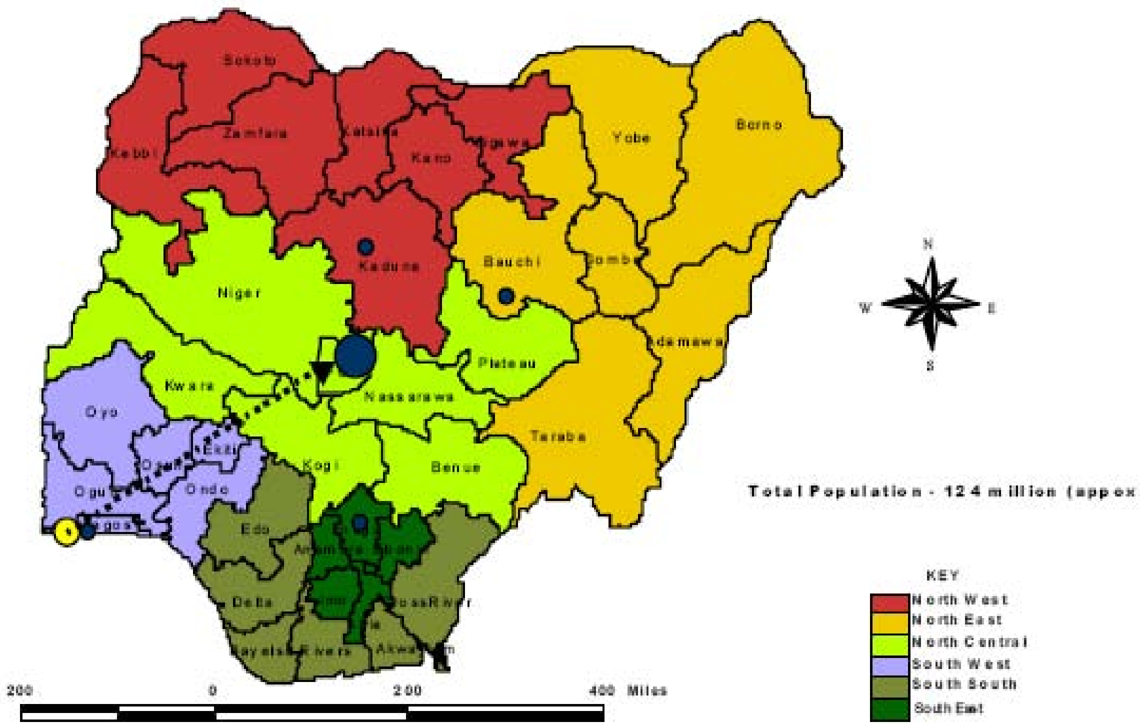
The Water, Sanitation and Hygiene (WASH) sector in Nigeria is faced with substantial policy, institutional and financial challenges. Water and sanitation has recently slipped from the federal government's top priorities. Although Nigeria has a comprehensive water and sanitation policy in place, safe excreta disposal is not any institution's primary responsibility,? (Pls check the Sanitation policy produced by the Federal Ministry of Environment) and hygiene remains an afterthought. Many states do not have WASH policies. The linkages between the Federal Ministry of Agriculture and Water Resources (FMAWR) – responsible for WASH programmes - and state Ministries of Water Resources, are weak. Problems across states include poor functionality, badly-designed tariff structures for sanitation? and underfunding of software such as community mobilization, sanitation and hygiene promotion, and operations and maintenance activities to support hardware facilities installed (WaterAid, 2009).

Water and sanitation services have been devolved to Local Government Agencies (LGAs) in every state. LGAs are solely responsible for ensuring access and use of these services. However, lack of autonomy, budget limitations; and poor capacity, have hampered their ability to carry out these duties effectively. The LGA WASH Units in donor-assisted states, tasked with management and implementation of various projects, are dynamic, energetic and display a higher capacity to deliver quality services than the LGAs in states where donors are not present. Civil society participation is limited and sector capacity is weak. Competing resource demands, partly caused by the consolidation of government ministries, has led to underfunding of water and sanitation in Nigeria. Expenditure has decreased in recent years and is inadequate to enable Nigeria to meet its MDG targets on water and sanitation. A lack of government–led donor harmonization further exacerbates the paucity of funding, resulting in disparate projects, duplication, and lack of lesson learning (WaterAid, 2009).

Nigeria has 12 million more people without access to safe water and another 40 million people without access to improved sanitation than it had in 1990.sixty five million out of an estimated population of 150 million do not have access to safe water supply. Also, over 100 million people do not have access to improved sanitation like latrines or toilets, and a large population practice open defecation. However, it not sufficient to provide communities with a supply of safe water and latrines, hygiene promotion is essential if people are to use the facilities properly and avoid water- and sanitation-related diseases. Lack of sanitation is not just a health issue; it affects girls' education and security (UNICEF, 2010).

According to WaterAid (nd?), provision of water and sanitation services without being demanded is like a support offered to an unwilling recipient. In many communities in Nigeria today, water and sanitation services are delivered not on demand but on assumption that people in such areas need them. Facilities provided in this manner are hardly used and often abandoned or vandalized.

The study locations



States with Sanitation Problems (Based On Soils)

State	Predominant Soil Type-	Rank
Bayelsa	Hydromorphic soils	1
Rivers	Hydromorphic soils	2
Delta	Hydromorphic soils	3
Lagos	Hydromorphic soils	4
Borno	Hydromorphic with weakly developed soils	5
Yobe	Hydromorphic with weakly developed soils	6
Benue	With significant amount of Hydromorphic soils	7
Kebbi	With significant amount of Hydromorphic soils	8
Nasarawa	With significant amount of Ferrisols soils	9
Niger	With significant amount of Ferrisols soils	10
Sokoto	With significant amount of weakly developed soil	11

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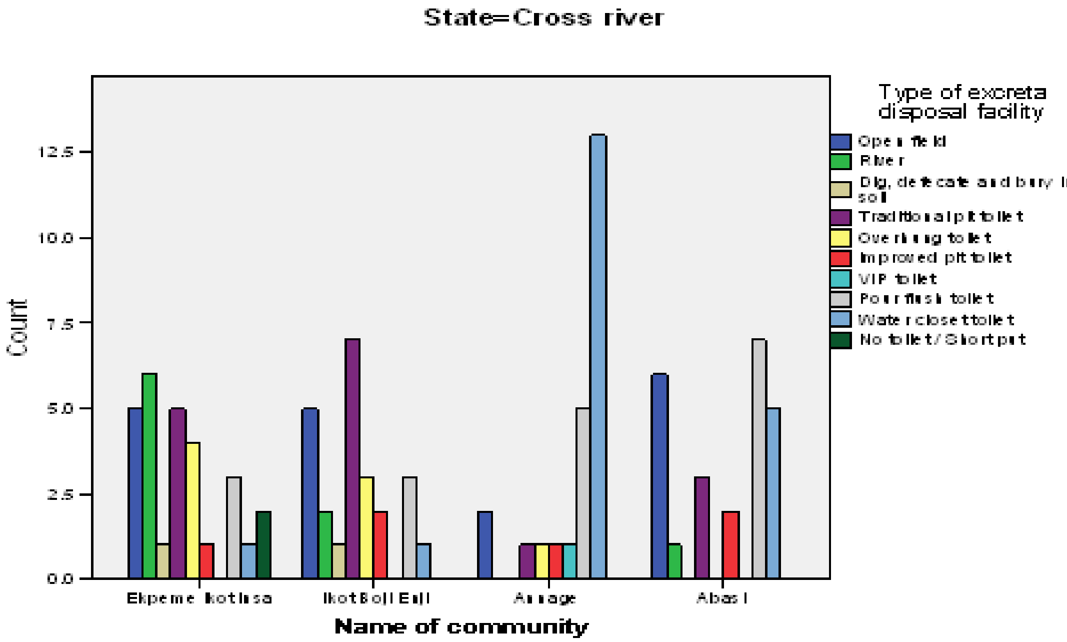
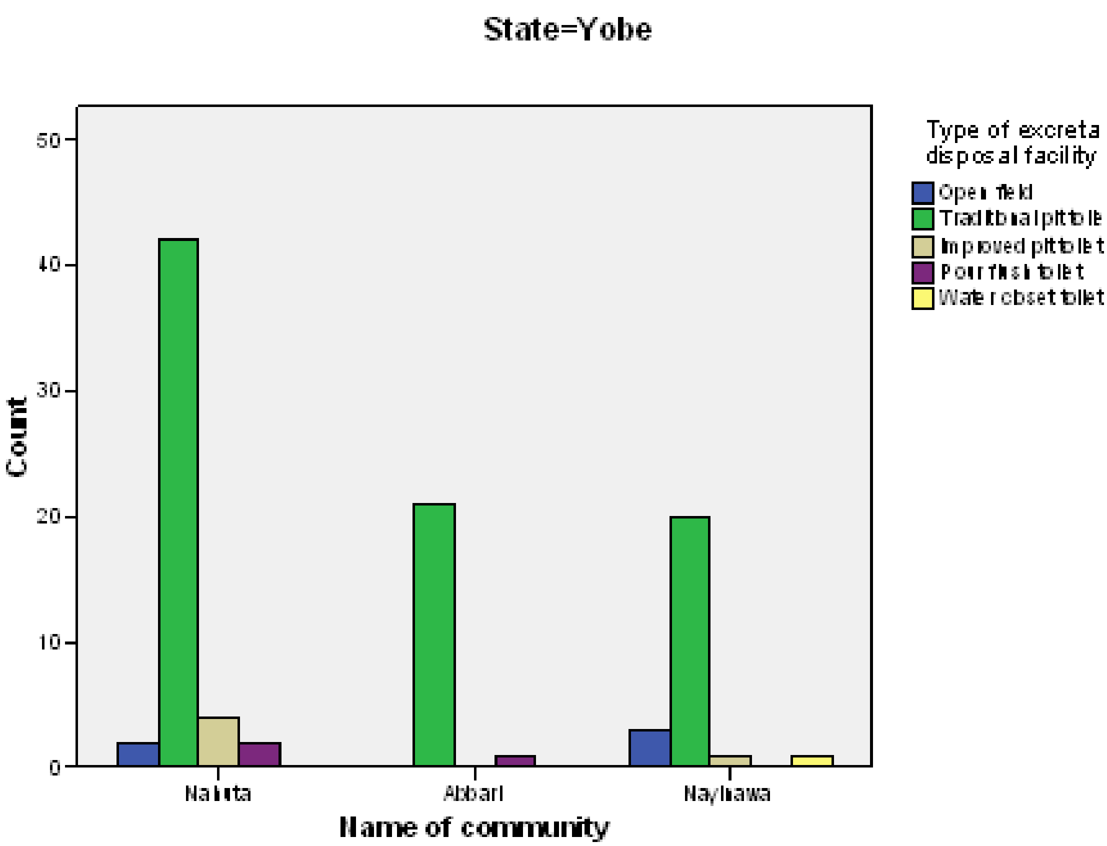
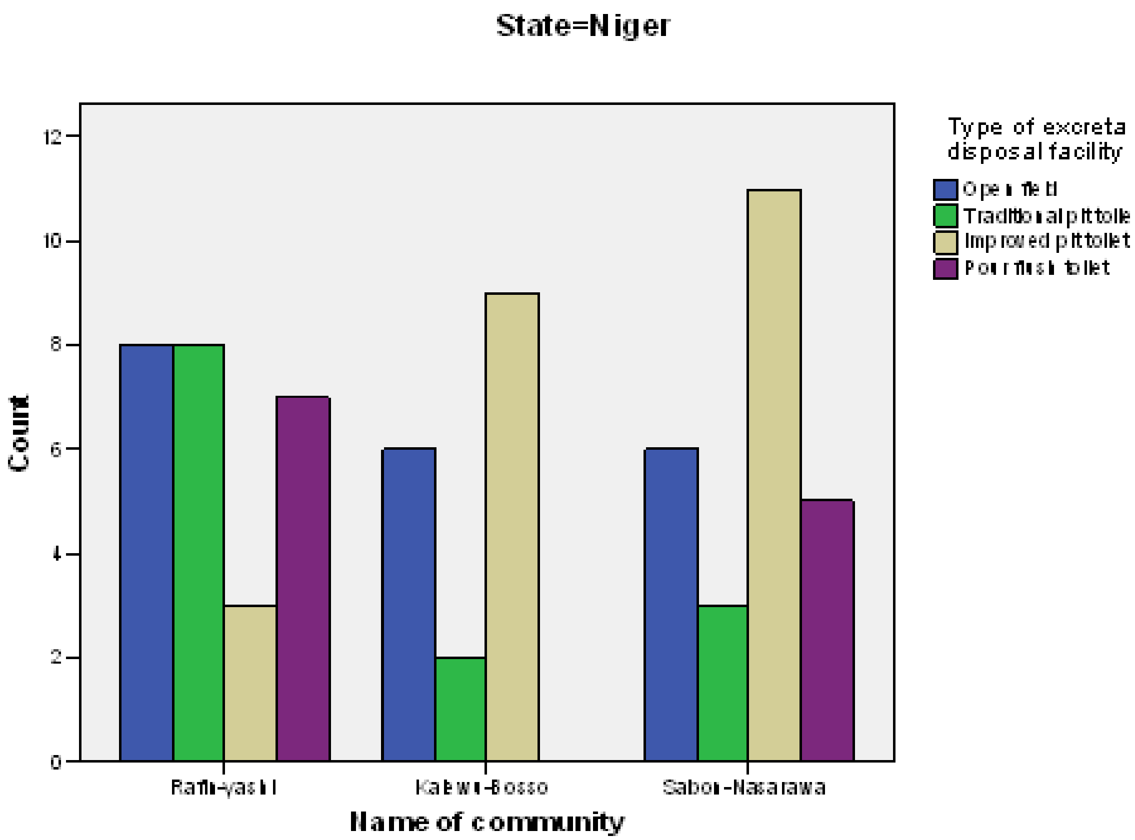
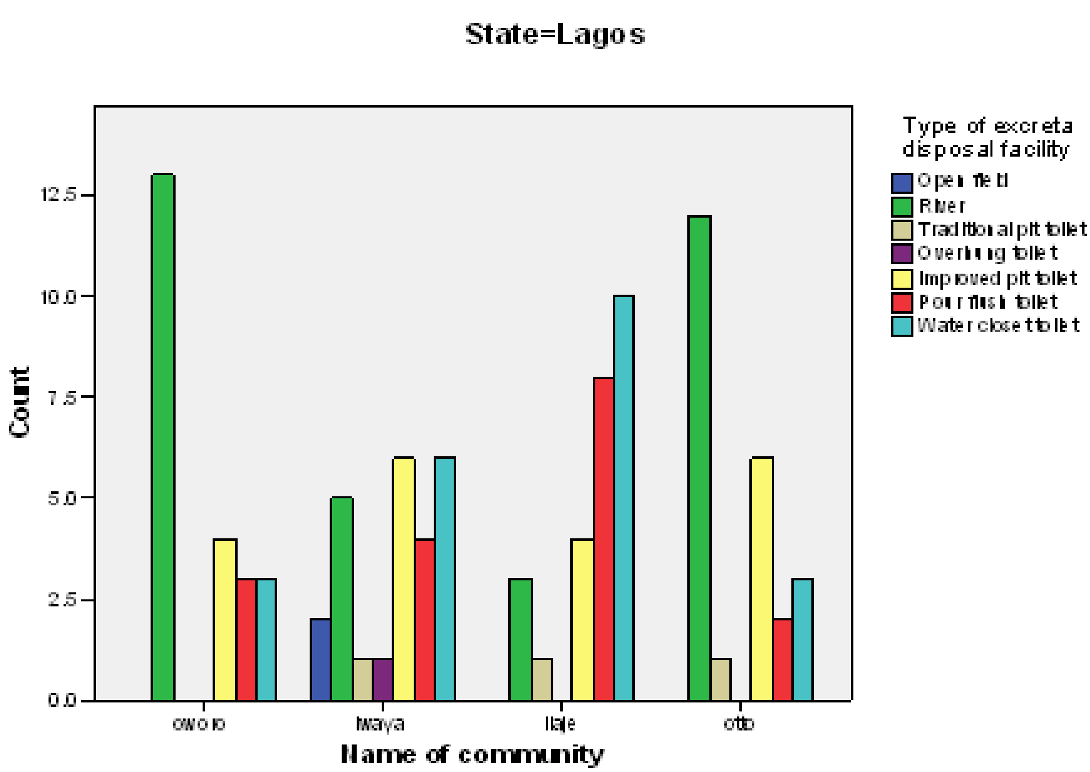
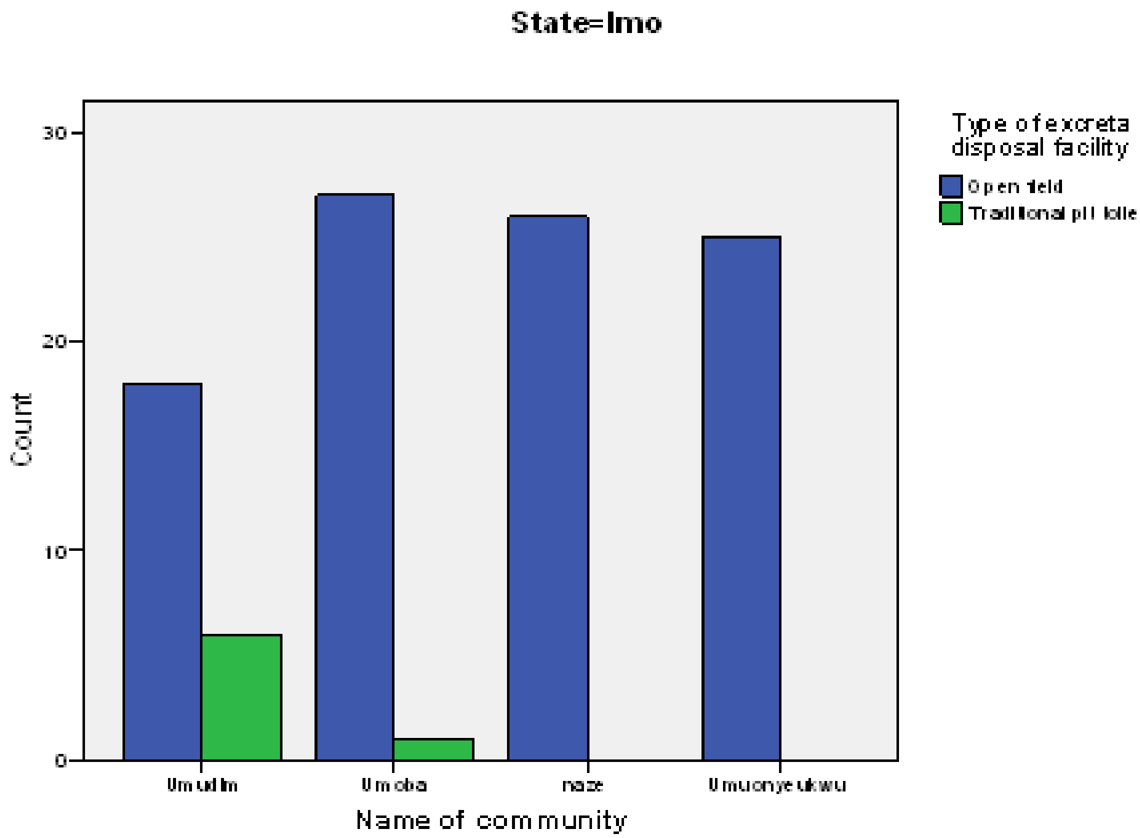
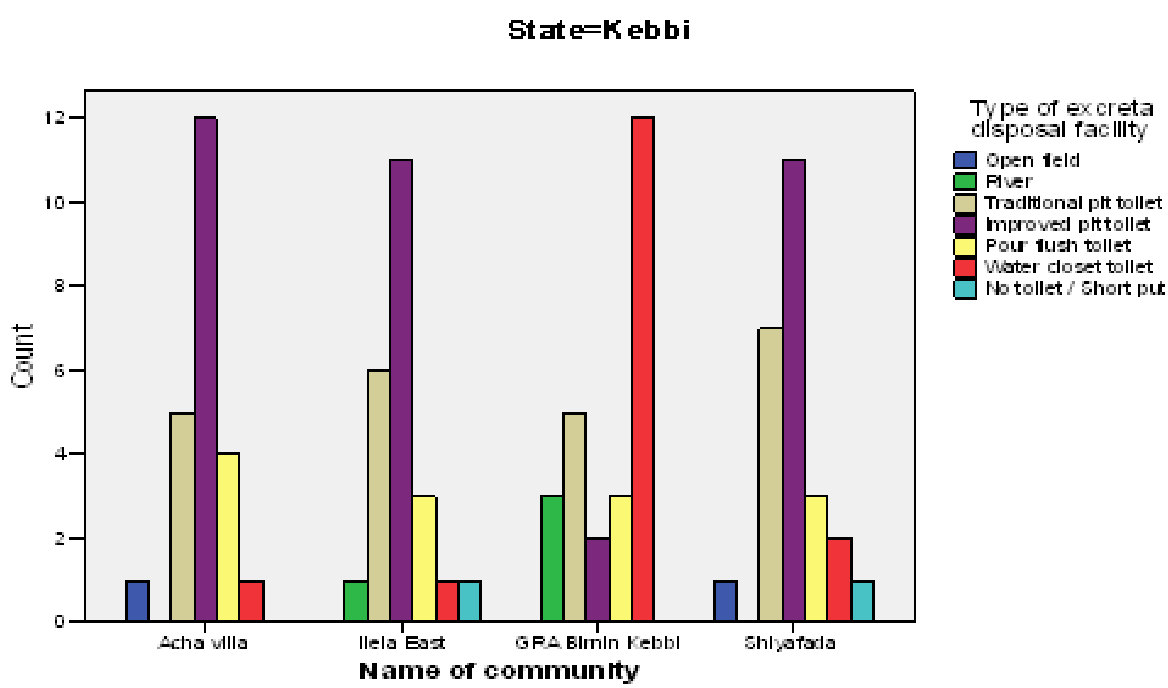

State=Cross river
Type of excreta disposal facility
Open field
River
Dig, defecate and bury in soil
Traditional pit toilet
Overhung toilet
Improved pit toilet
VIP toilet
Pour flush toilet
Water closet toilet
No toilet/Short pit
Count
12.5
10.0
7.5
5.0
2.5
0.0
Ekpeme Ikot Insa
Ikot Bojl Ebjl
Anage
Abasi
Name of community

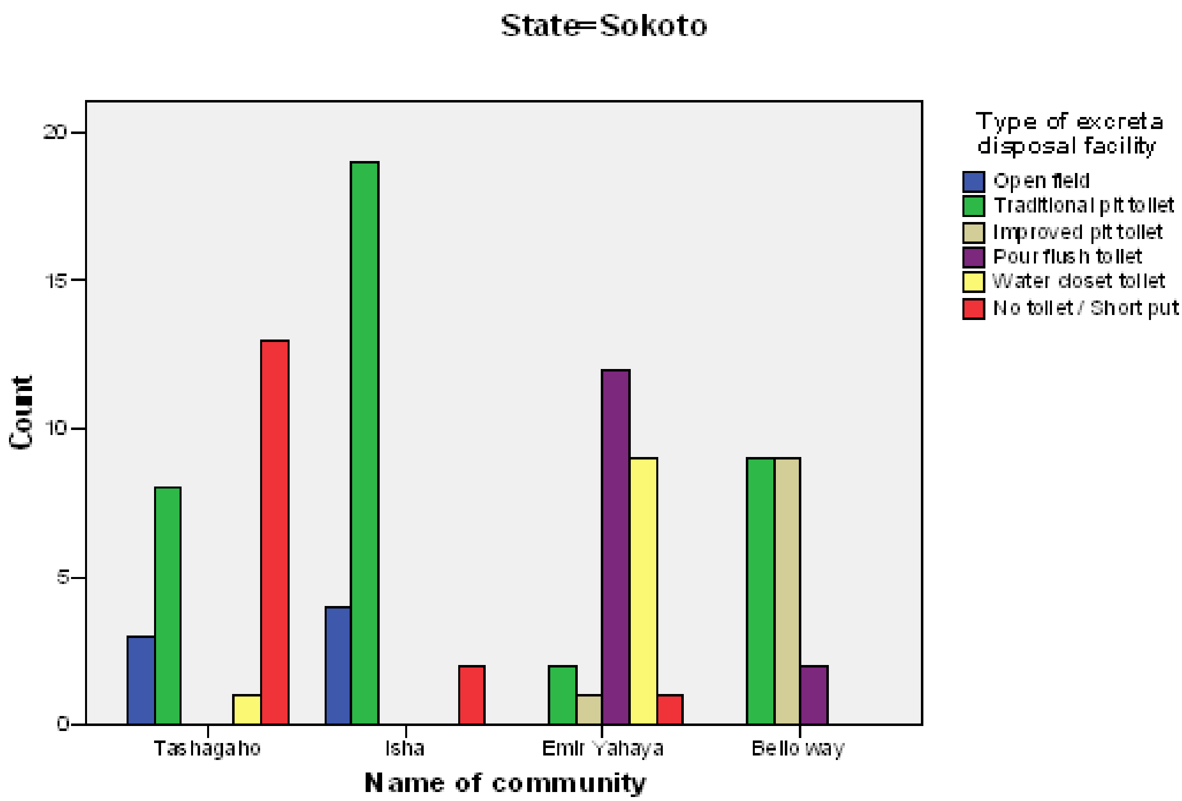

State=Yobe
Type of excreta disposal facility
Open field
Traditional pit toilet
Improved pit toilet
Pour flush toilet
Water closet toilet
Count
50
40
30
20
10
0
Nakuta
Abbari
Nayinawa
Name of community

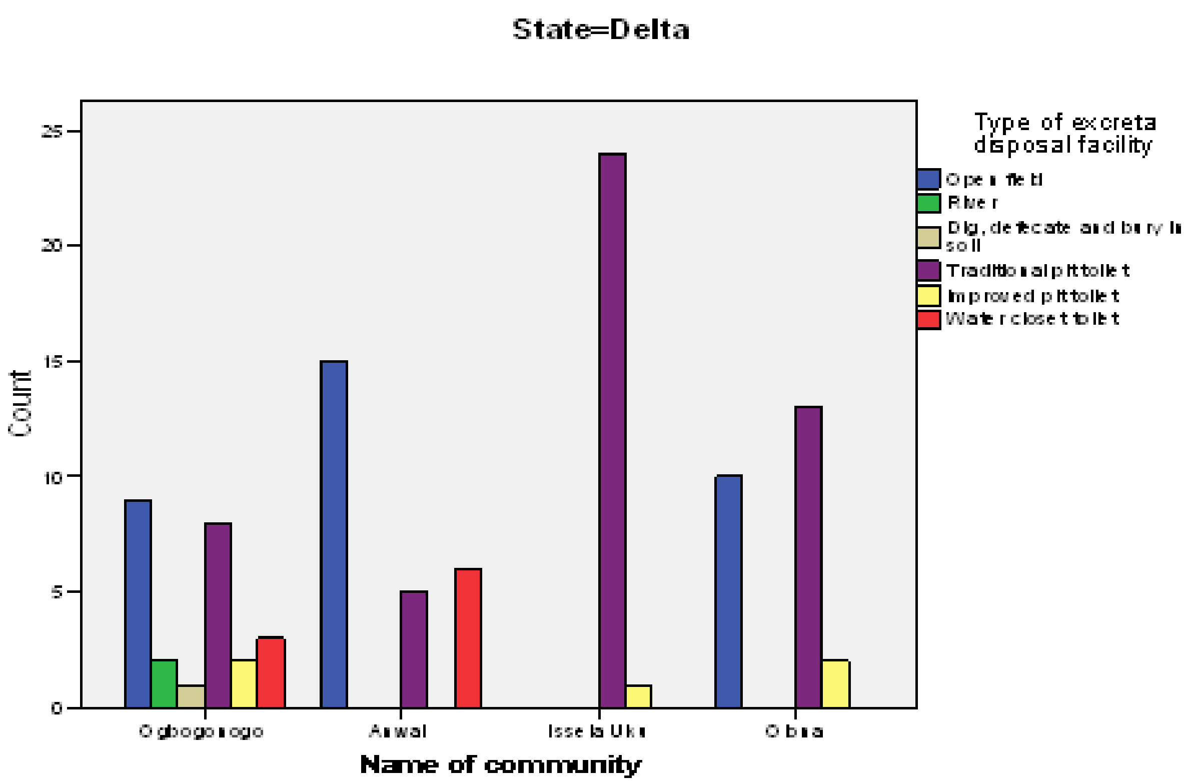

State=Niger
Count
12
10
8
6
4
2
0
Rafin-yashi
Sabon-Nasarawa
Name of community
Type of excreta disposal facility
Open field
Traditional pit toilet
Improved pit toilet
Pour flush toilet

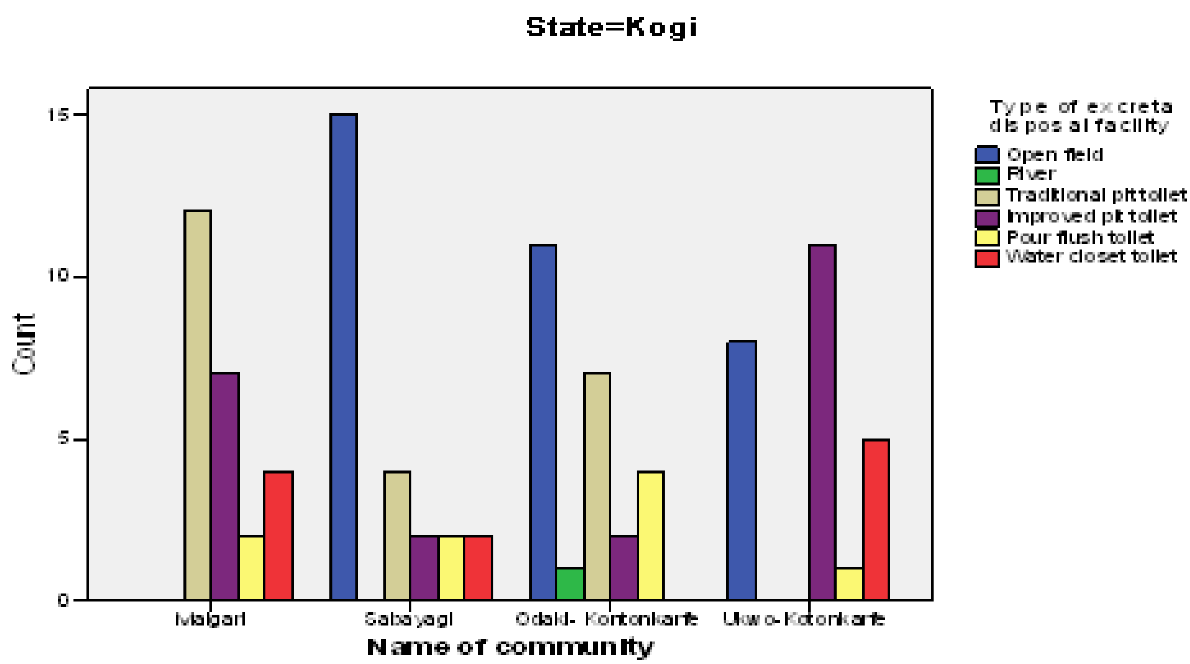

State=Lagos
Count
12.5
10.0
7.5
5.0
2.5
0.0
oworo
Iwaya
Ilaje
otto
Name of community
Type of excreta disposal facility
Open field
River
Traditional pit toilet
Overhung toilet
Improved pit toilet
Pour flush toilet
Water closet toilet

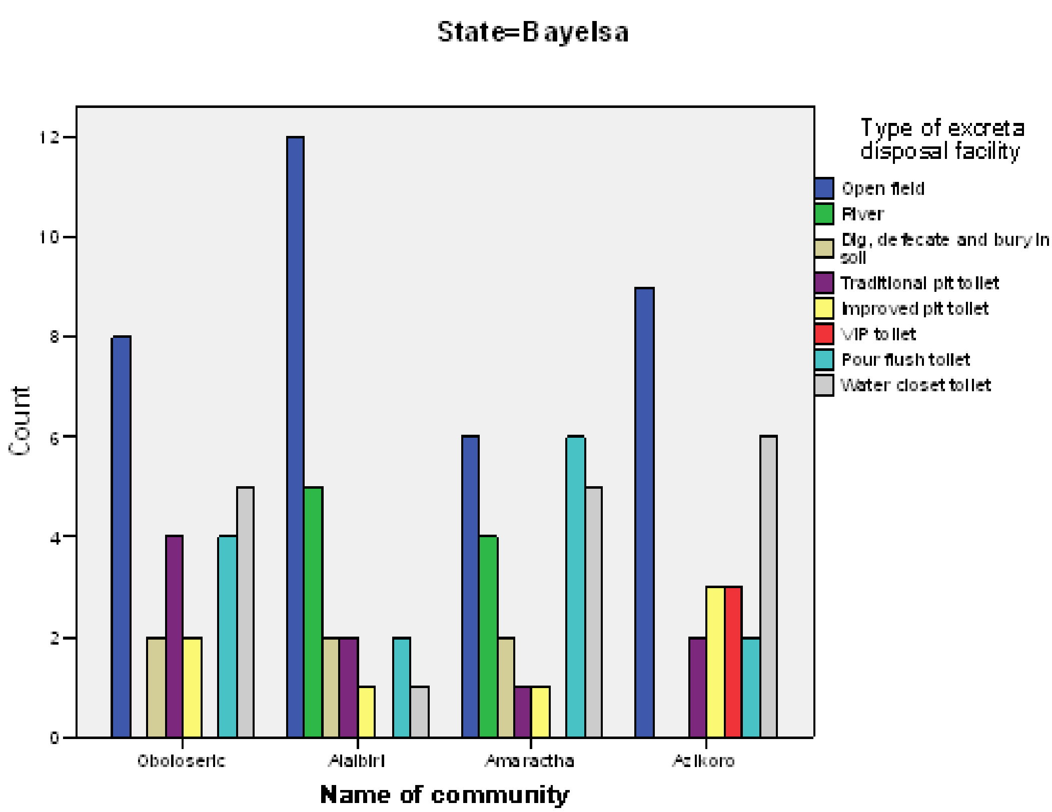

State=Imo
Count
30
20
10
0
Umudim
Umoba
naze
Umuonyeukwu
Name of community
Type of excreta disposal facility
Open field
Traditional pit toilet


State=Kebbi
Count
12
10
8
6
4
2
0
Acha villa
Ilela East
GRA Birnin Kebbi
Shiyafada
Name of community
Type of excreta disposal facility
Open field
River
Traditional pit toilet
Improved pit toilet
Pour flush toilet
Water closet toilet
No toilet / Short put


State=Sokoto
Count
20
15
10
5
0
Tashagaho
Isha
Emir Yahaya
Bello way
Name of community
Type of excreta disposal facility
Open field
Traditional pit toilet
Improved pit toilet
Pour flush toilet
Water closet toilet
No toilet / Short put


State=Delta
Count
25
20
15
10
5
0
Name of community
Type of excreta disposal facility
River
Traditional pit toilet
Improved pit toilet
Water closet toilet


State=Kogi
Count
Type of excreta disposal facility
Open field
River
Traditional pit toilet
Improved pit toilet
Pour flush toilet
Water closet toilet
Name of community


State=Bayelsa
Count
Type of excreta disposal facility
Open field
River
Dig, defecate and bury in soil
Traditional pit toilet
Improved pit toilet
VIP toilet
Pour flush toilet
Water closet toilet
Oboloseric
Alaibiri
Amaractha
Azikoro
Name of community

	Constraints for toilet construction	Floods	Floating riverine	Loose soils	High waterta ble	Hard rocky	No water / mone y	Total
Total All State s	Count	431	44	43	44	138	110	810
	% within State	53.2%	5.4%	5.3%	5.4%	17.0%	13.6%	100.0 %
	% within What would you consider to be the major challenge(s)	100.0%	100.0%	100.0%	100.0%	100.0%	100.0 %	100.0 %
	% of Total	53.2%	5.4%	5.3%	5.4%	17.0%	13.6%	100.0 %

Presence of Superstructure

Problems of facilities

State	Leakages, %	High water table, %	Collapsed, %
Kogi	24.3	8.1	8.1
Cross River	6.3	3.1	6.3
Niger	0	0	4.8
Bayelsa	9.5	4.8	9.5
Yobe	16.7	8.3	20.8
Lagos	5.6	16.7	0
Kebbi	6.5	6.5	6.5
Sokoto	12.5	12.5	12.5
Imo	-	36.1	-
Delta	2.5	5.0	-

Preference for new toilets

State	Pour Flush, %	Improved toilet, %	WC, %	Traditional, %
Kogi	12.5	25.0	20.0	-
Cross River	14.3	5.7	54.3	-
Niger	15.8	31.6	7.9	-
Bayelsa	38.7	16.1	38.7	-
Yobe	-	-	-	86.0
Lagos	19.4	-	77.8	-
Kebbi	-	2.8	11.8	86.3
Sokoto	-	-	5.0	96.0
Imo	-	-	-	100.0
Delta	-	-	-	90.2

YOBE

LAGOS

IMO

VIII. The Challenges

From the study so far, the challenges seem to be:

- Communities are aware of their needs of sanitation
- Given an opportunity, they prefer water closet or septic tanks in the south eastern region;
- In the north traditional pit latrines are preferred possibly due to their religious and cultural background; some communities also preferred upgrading the toilet facility to a better system; pour-flush system is acceptable in several places
- Finances/poverty are a major concern;
- In some locations the hydro-geological nature of soil is affecting the quality of sanitation system to be put in place; this demands only certain types which can withstand the soil type;
- Culturally, blocks, cement and iron materials are used in the construction of the toilets;
- Communities are ready to go for a better sanitation system if available and migrate from the present practices.

VIP TOILETS (STEP BY STEP)

Caring the Disabled (Bungudu)

This is the first time an equal-access latrine has been constructed in Nafisa's school. The UNICEF-supported structure offers a concrete wheelchair ramp as well as a set of crutches and other forms of stability. In place of the traditional hole, there is an easy-to-clean seat. The door is wide enough to accommodate a wheelchair and Nafisa was able to wash her hands without difficulty.

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Which way forward to meet the challenges?

- **A few model sanitary units appropriate and suitable in various hydrogeolical zones will be a way forward as demonstration units which can be replicated by the communities with the assistance from LG, NGOs, and other agencies.**
- **Choose what you want from the World Toilet museum !!**

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Sanitation and Personal Hygiene: Antidote to Cholera Epidermic Outbreak in Challenging Environment in Nigeria

By Abogan Olutayo Samson
Osun State College Of Technology, Nigeria

Abstract- This study sought to determine the solution to cholera outbreak in the challenging environment in Nigeria. More than 100,000 people die from the disease every year, with the majority of cases in Sub-Saharan Africa.[1] It is estimated that cholera affects 3-5 million people worldwide[1], and causes 100,000-130,000 deaths a year as of 2010.[2] This occurs mainly in the developing world and Nigeria happens to be one of such developing countries.[2] More than 100,000 people die from the disease every year, with the majority of cases in Sub-Saharan Africa.[1] Although cholera may be life-threatening, prevention of the disease is normally straightforward if proper sanitation practices are followed. Effective sanitation practices, if instituted and adhered to.

GJHSS-B Classification : FOR Code: 969999p

SANITATIONANDPERSONALHYGIENEANTIDOTETOCHOLERAEPIDERMICOUTBREAKINCHALLENGINGENVIRONMENTINNIGERIA

Strictly as per the compliance and regulations of:

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Abogan Olutayo Samson

Abstract- This study sought to determine the solution to cholera outbreak in the challenging environment in Nigeria. More than 100,000 people die from the disease every year, with the majority of cases in Sub-Saharan Africa.[1] It is estimated that cholera affects 3-5 million people worldwide[1], and causes 100,000-130,000 deaths a year as of 2010.[2] This occurs mainly in the developing world and Nigeria happens to be one of such developing countries.[2] More than 100,000 people die from the disease every year, with the majority of cases in Sub-Saharan Africa.[1] Although cholera may be life-threatening, prevention of the disease is normally straightforward if proper sanitation practices are followed. Effective sanitation practices, if instituted and adhered to.

In- Depth Interview (IDI) guide was developed. This instrument is in four sections which captured the following topics; excreta disposal facilities preference for safe excreta facility and excreta disposal and sanitation challenging. The team paid a visit to, two states namely Sokoto and Kebbi States due to the peculiarity of these environments. In each state, 2 L.G.A were visited in both urban and rural areas which 4 communities were selected based on the socio-economic status of the residents. 10 respondents were interviewed per community being carefully selected among the stakeholders at local level.

The study discovered that, the rocky topographical structure, loose soil texture, heavy rainfall and poor drainage which causes flooding and pollution of water surfaces like Rivers and Lake which also, serves as their source of drinking water.The study reveals the correlation between cholera and contaminated drinking water. Further findings, in this study shows that most of the mass hospitalization and disease out break that occurred in recent time, in the area visited; were as a result of poor sanitation, pollution of the environments, water surfaces with excreta, open defecation and flooding of soak away.

In conclusion, proper sanitation is the only way out; in preventing cholera outbreak. Therefore the issue of sanitation is highly paramount, although cholera may be life-threatening prevention of the disease is normally straightforward if proper sanitation practices are followed.

I. Introduction

Sanitation is a long-standing, public health issue. When early peoples settled in communities and started to cultivate crops and raise animals, sanitation became a primary concern for society. Inadequate sanitation is a major cause of disease world-wide and improving sanitation is known to have a significant beneficial impact on health both in households and across communities. Good basic personal hygiene and hand washing are critical to help prevent the spread of illness and disease. Keeping hands clean helps prevent the spread of germs. Hand washing with soap is the best way to reduce the number of germs on them.

Bad sanitation and poor hygiene have to coincide with people carrying the Vibrio Cholerae before cholera outbreak could occur.

Cholera is one of the most widespread and deadly diseases of the 19th century, killing an estimated tens of millions of people. It is estimated that cholera affects 3-5 million people worldwide, and causes 100,000-130,000 deaths a year as of 2010. [2] This occurs mainly in the developing world. More than 100,000 people die from the disease every year, with the majority of cases in Sub-Saharan Africa. [1]Cholera remains both epidemic and endemic in many areas of the world.

One of the major contributions to fighting cholera was made by the physician and pioneer medical scientist John Snow in his epidemiological field studies, found a link between cholera and contaminated drinking water. [1] He was able to demonstrate, that human sewage contamination was the most probable disease vector in cholera epidemics outbreak. [1] Worldwide, 40 percent of the population does not have ready access to clean, safe drinking water, and approximately 60 percent does not have satisfactory facilities for the safe disposal of human waste. Infectious agents in drinking water and food cause the diarrheal deaths of several million children annually. Whereas, waterborne agents are the cause of many diseases in the world.(Diarrhoea, Guinea worm, Typhoid Fever ,Dysentery, Malaria, Ring worm and Cholera). Therefore the issue of water sanitation is highly paramount. Water sanitation is directly related to water quality and water pollution. Water quality usually describes the level of certain compounds that could present a health risk.

Generally, the climate of Nigeria does not pose serious problem for sanitation as such. Except for recent times, when high variability and extremes particularly with rainfall have been attributed to climate

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e-mail:olu_laughter2013@yahoo.co.uk

change. As such, only the littoral states (i.e. Lagos, Edo, Delta, Bayelsa, Rivers, Akwa Ibom, Cross River, Ogun and Ondo) which receive the most of rainfall all year round and perhaps the least of temperature may be prone to being water bound which may constitute some challenge for sanitation. Another impinging factors are topographical nature of an area couple with the soil texture in some part of the country. (Sokoto and kebbi states)

Sanitation: is the hygienic means of promoting health through prevention of human contact with the hazards of wastes. Hazards can be physical, microbiological, biological or chemical agents of disease. Wastes that can cause health problems are human and animal feces, solid wastes, domestic wastewater (sewage, sullage, greywater), industrial wastes, and agricultural wastes. Sanitation is a long-standing, public health issue. When early peoples settled in communities and started to cultivate crops and raise animals, sanitation became a primary concern for society.

Inadequate sanitation is a major cause of disease world-wide and improving sanitation is known to have a significant beneficial impact on health both in households and across communities. Worldwide, 40 percent of the population does not have ready access to clean, safe drinking water, and approximately 60 percent does not have satisfactory facilities for the safe disposal of human waste. Infectious agents in drinking water and food cause the diarrheal deaths of several million children annually.

Waterborne agents are the cause of many diseases in the world. (Diarrhoea, Guinea worm, Typhoid Fever, Dysentery, Malaria, Cholera and Ring worm) These diseases may be caused by bacteria, viruses, and protozoans. Bacterial diseases include typhoid, shigellosis, and cholera. Viral agents cause diseases such as include polio and hepatitis. Parasites include the protozoa Entamoeba histolytica and Giardia lambdia, which cause amebiasis and giardiasis, respectively. Another example of sanitation as it relates to waterborne diseases globally is schistosomiasis. Schistosomiasis is a chronic debilitating disease with significant morbidity and mortality that affects more than 200 million people worldwide.

a) Concept of Sanitation

The word 'sanitation' also refers to the maintenance of hygienic conditions, through services such as garbage collection and wastewater disposal. [5] The word "sanitation" entered the English language in the nineteenth century, and the term is inextricably linked with integrated water and sewer systems. Sanitation includes the appropriate disposal of human and industrial wastes and the protection of the water sources. World Health Organization states that: "Sanitation generally refers to the provision of facilities and services for the safe disposal of human urine and faeces. According to Saunders Veterinary Dictionary Sanitation is the establishment of conditions favorable to health, especially with respect to infectious diseases. This includes disposal of infective materials, especially carcasses, discharges and excrement, application of disinfectants and general cleaning to make disinfection effective, isolation of infective animals and improvement in ventilation of buildings, improving feeding and watering arrangements to avoid fecal and urinary contamination of food and water.

The term *"sanitation"* can be applied to a specific aspect, concept, location, or strategy, such as:

Basic sanitation - refers to the management of human feces at the household level. This terminology is the indicator used to describe the target of the Millennium Development Goal on sanitation.

On-site sanitation - the collection and treatment of waste is done where it is deposited. Examples are the use of pit latrines, septic tanks, and Inhofe tanks.

Food sanitation - refers to the hygienic measures for ensuring food safety.

Environmental sanitation - the control of environmental factors that form links in disease transmission. Subsets of this category are solid waste management, water and wastewater treatment, industrial waste treatment and noise and pollution control.

Ecological sanitation - a concept and an approach of recycling to nature the nutrients from human and animal wastes.

b) Personal Hygiene

Good basic personal hygiene and hand washing are critical to help prevent the spread of illness and disease. Clean, safe running water is essential for proper hygiene and hand washing. Keeping hands clean helps prevent the spread of germs. Washing your hands with soap and safe water is the best way to reduce the number of germs on them. If soap and water are not available, use an alcohol-based hand sanitizer that contains at least 60% alcohol.

Follow these steps to make sure you wash your hands properly:

Wet your hands with clean, running water (warm or cold) and apply soap.
Rub your hands together to make lather and scrub them well; be sure to scrub the backs of your hands, between your fingers, and under your nails.
Continue rubbing your hands for at least 20 seconds.
Rinse your hands well under running water.
Dry your hands using a clean towel or air dry them.

When to Wash Hands

Before, during, and after preparing food
Before eating food

Immediately after defecation and urination with safe water and soap/ash when soap is not available.
After changing diapers or cleaning up a child who has used the toilet.
Before and after caring for someone who is sick.
After blowing your nose, coughing, or sneezing.
After touching an animal or animal waste.
After touching garbage.
Before and after treating a cut or wound.

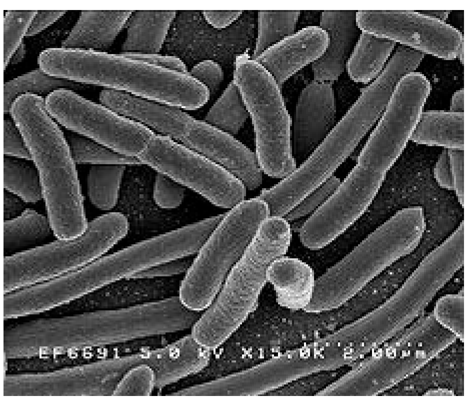
Apart of from the various ways mentioned above, individuals should also adhere to certain personal hygiene, these prevent the spread of germs and diseases. Toilets should be washed daily with soap and disinfectants. Compounds and environments be kept clean on a daily bases.

Households refuse disposition be done in appropriate manner either burning /garbage pit.

Stagnant water in the environment disposed because these can habour vectors.

c) What Is Cholera?

Cholera is an infection of the small intestine, an acute infectious disease caused by a bacterium, Vibrio cholerae (V. cholerae). Robert Koch identified V. cholerae with a microscope as the bacillus causing the disease.



E. coli bacteria under magnification

Epidemics of Vibrio Cholerae are caused by one of two strains: 01, and strain 0139. Bad sanitation and hygiene have to coincide with people carrying the Vibrio Cholerae bacterium for the outbreak of the epidemic.Cholera is one of the most widespread and deadly diseases of the 19th century, killing an estimated tens of millions of people.[5] It is estimated that cholera affects 3-5 million people worldwide[1], and causes 100,000-130,000 deaths a year as of 2010.[2] This occurs mainly in the developing world.[2] More than 100,000 people die from the disease every year, with the majority of cases in Sub-Saharan Africa. In the early 1980s, death rates are believed to have been greater than 3 million a year. [1] Cholera was one of the earliest infections to be studied by epidemiological methods. Cholera remains both epidemic and endemic in many areas of the world. [1].

John Snow was the first to identify the importance of contaminated water in its cause. [2] Transmission is primarily due to the fecal contamination of water and due to poor sanitation. In developed Countries cholera is typically transmitted by either contaminated water or food, while in the developing world it is more often water Cholera.

The source of the contamination is from individuals infected by cholera, when their untreated diarrheal discharge gets into waterways or into groundwater or drinking water supplies. Also, lack of treatment of human feces and drinking water greatly facilitate its spread, but bodies of water can serve as a reservoir, and seafood shipped long distances can spread the disease. Drinking any infected water and eating any foods washed in the water, can cause a person to contract an infection. Cholera is rarely spread directly from person to person. For every symptomatic person there are 3 to 100 people who get the infection but remain asymptomatic. [7] 75% of people infected with Vibrio Cholerae do not develop symptoms. But they excrete the bacterium with their faeces for up to 14 days a potential source of infection for others.

i. *symptoms*

The main symptoms are profuse watery and painless diarrhoea and vomiting of clear fluid that often contains flecks of whitish material (mucus and some epithelial cells) [8] that are about the size of pieces of rice. The diarrhea is frequently described as "rice water" in nature and smells fishy. Symptoms usually start suddenly, one to five days after ingestion of the bacteria. [1] The severity of the diarrhea and vomiting can lead to rapid dehydration and electrolyte imbalance. Although cholera may be life-threatening, prevention of the disease is normally straightforward if proper sanitation practices are followed. Effective sanitation practices, if instituted and adhered to in time, are usually sufficient to stop an epidemic.

The following symptoms and signs may develop.

Vomiting, Rapid heart rate, Loss of skin elasticity, Dry mucous membranes, Low blood pressure, Thirst, Muscle cramps and Restlessness or irritability (especially in children)

Treatment of Cholera

If the severe diarrhea and vomiting are not aggressively treated it can, within hours, result in life-threatening dehydration, in some cases even death. Resulting from loose of copious amount of body fluids.[1] Primary treatment is with oral rehydration solution. If people with cholera are treated quickly and properly, the mortality rate is less than 1%; however, with untreated cholera, the mortality rate rises to 50–60%.[1][9] In most cases, cholera can be successfully treated with oral rehydration therapy (ORT),which is highly effective, safe, and simple to administer.[10] Rice-based solutions are preferred to glucose-based ones due to greater efficiency.[10] One such recipe calls for 1 liter of boiled water, 1 teaspoon of salt, 8 teaspoons of sugar, and added mashed banana for potassium and to improve taste.[11] In severe cases with significant dehydration, intravenous rehydration may be necessary.

d) Ecological Setting of Nigeria

A brief description of the vegetation of Nigeria provides a basis for the ecological zoning of the country which also has close links to climatic zonation.

The total area of Nigeria is 923,768 km². 910,768 km² of that is land, while water takes up 13 000 km². Nigeria's total boundaries are 4 047 km in length. The countries it borders account for most of this. The border with Benin is 773 km, which with Cameroon is 1,690 km, Chad's is 87 km, and Niger's is 1,497 km. Nigeria's coastline is 853 km.

Nigeria's vegetation can be broadly grouped into three main categories. The vast majority of Nigeria's vegetation falls within only two categories namely rain forest and savannah while the third category is montane vegetation. It is very small compared to savannah and rain forest. Is at the extreme east close to Cameroon. While there is a diversity of vegetation patterns within each of these categories, the major physical distinction between rain forest areas and savannah areas is the density of tree cover.

In savannahs, trees are much more widely spaced than in rain forests. Between interspersed trees, savannahs are marked by grasses of varying lengths. The rain forest contain little, if any grass cover and are typically marked by different layers of tree cover. The southern part of Nigeria is dominated by thick mangrove swamps in the immediate coastal regions (particularly in the Niger Delta and in the extreme southeast part of the country), and by rain forests. Further north, the dense rain forests give way to savannahs with dispersed trees. In the extreme northeastern part of the country near Lake Chad, scrub vegetation is dominant.

Below is a list of the seven vegetation sub-types, followed by a general geographical.location of each zone. Note that the list generally proceeds from south to north.

Salt-water swamp - lower Niger Delta and southeast Nigeria around the city of Calabar

Fresh-water swamp - upper Niger Delta and coastal strip from Port Harcourt to Lagos

Rain forest - general east-west strip across southern Nigeria whose average width is approximately 130 km

Guinea savannah - largest vegetation zone, lies just north of the rain forest and reaches northward as far Lake Kainji, Zaria, and the Benue River in the East

Sudan savannah, north of the guinea savannah, covering most of the rest of Nigeria

Sahel savannah, covers a small pocket of Nigeria that borders lake Chad

Montane, parts of the eastern highlands bordering Cameroon and parts of the Jos Plateau

i. *Locational Attributes*

Nigerian, with a total land area of approximately 923,773 km2 and a coast line which extends about 853 km along the Atlantic Ocean, lies essentially within the tropical climatic zone approximately between the latitudes 4oN and 14oN and between longitude 13oE and 15oE. The country world's 32nd largest country (after Tanzania, is located in West Africa and shares land borders with the Republic of Benin in the west, Chad and Cameroon in the east, and Niger in the north. Its coast in the south lies on the Gulf of Guinea on the Atlantic Ocean While temperatures rarely exceeds 350(900F) with high humidity (up to 90% in the morning) in the south, in the central and northern parts, temperature could be as high as 38o C (1000F) but with relatively cool nights. The annual rainfall is equally less than 500mm in some parts of the north and greater than 2300 mm in some parts of the south. While the duration of rainfall period varies between 100 and 230 days in the northern Nigeria, it ranges between 270 and 300 days in the Niger-Delta in the south.

Nigeria's most expansive topographical region is that of the valleys of the Niger and Benue River valleys. To the southwest of the Niger there is "rugged" highland, and to the southeast of the Benue are hills and mountains which form the Mambilla Plateau, the highest Plateau in Nigeria. This plateau extends to the border with Cameroon, thus forming part of the Bamenda Highlands in Cameroon. The area near the border with Cameroon close to the coast is a rich rainforest and part of the Cross-Sanaga-Bioko Coastal forests eco-region, an important centre for biodiversity including the drill monkey which is only found in the wild in this area and across the border in Cameroon.

ii. *Drainage of Nigeria*

Nigeria is a very well drained country with numerous consequent and subsequent rivers. Most of the rivers in the country take their source from within the country flowing either to connect a larger river or to empty into the ocean. Apart from Rivers Niger and Benue which are regional rivers to a large extent, almost all other rivers are local within Nigeria.

e) Analysis of Challenges of Drainage on Sanitation

The presence of water bodies is a factor which challenges sanitation facilities, the implication is often not debilitating without a combination with soil and geology of the area. The drainage network characterizes the presence of water within the administrative boundary of the different states of the country upon which ranking of the possible challenges to sanitation is based. The Table 1 below reflect different states in which flooding are imminent .Thus, flood ranges from mostly prone, prone, rarely prone, and least floodable states

Table 1

States in Nigeria	Flood Range
Kaduna, Kano, Gombe, Edo, Delta, Cross River, Bayelsa, Kogi, Lagos, Niger, Rivers, Zamfara and Bauchi	Mostly prone to flooding anytime of the year
Taraba, Sokoto, Oyo, Osun, Ondo ,Ogun, Kawra, kebbi, Kastina, Jigawa, Imo, FCT, Ekiti, and Adamawa.	Prone to flooding only due to extreme rainfall and other flooding causes particularly during the raining season
Yobe, Plateau, Nasarawa, Enugu, Ebonyi, Anambra, Akwa Ibom and Abia.	Rarely prone to flooding except on occasion of extreme events, dam failure or poor drainage management particularly in the urban areas.
Borono	Least floodable due to drainage network

II. Methodology

a) Instruments Development

In- Depth Interview (IDI) guide Direct Observations and submitted for approval from UNICEF and other stakeholders for comments and additions before setting out for field work. This instrument was divided into four sections which captured the following topics; excreta disposal facilities, preference for safe excreta facility and excreta disposal and sanitation challenges.

b) Sampling Frame

Among the eight states visited, namely; Imo, Kogi Delta, Niger, Sokoto, Kebbi, Balyesa and Cross river, this team paid a visit to, two state namely Sokoto and Kebbi States; Due to the peculiarity of these environments. In each state, 2 L.G.A were visited in both urban and rural areas which 4 communities were selected based on the socio-economic status of the residents. 10 respondents were interviewed per community being carefully selected among the stakeholders at local level.

III. Discussion and Findings

In this study it was discovered that, the rocky topographical structure of the community visited [Ilela] posed a challenge with regards to sanitation and excreta facility. Some respondents complained about the poor drainage of the area which a time causes flooding of soakaways. It resultant effect is the pollution of water surfaces like Rivers and Lake which also, serves as their source of drinking water.

Geological characteristic some how, made excreta disposal a sort of challenge, according to the finding in this study, some respondents mentioned that; the loose texture of the soil exacerbate the collapse of the toilets which made some occupant left with the choice of open defecation .

Furthermore, most of the respondents affirmed to the fact that the major cause of the disease out break(cholera and diahhoral) in the community could be as a result of poor sanitation, flooding of soak away especially during raining seasons. This is to buttress the finding of John Snow in his epidemiological field studies, which reveals a correlation between cholera and contaminated drinking water. [38] He was able to demonstrate, that human sewage contamination was the most probable disease vector in cholera epidemics outbreak. [39]

Further findings, in this study shows that most of the mass hospitalization and disease out break that occurred in resent time in the area visited were as a result of poor sanitation, pollution of the environments, water surfaces with excreta, open defecation and flooding of soakaway. This support the opinion that, waterborne agents are the cause of many diseases in the world.(Diarrhoea, Guinea worm, Typhoid Fever, Dysentery, Malaria, Ring worm and Cholera).

IV. Recommendation

The following are recommendations made by the some of the respondents.

- Proper maintenance of toilets should be promoted among people to avoid the spread of diseases.
- People should be enlightening about the dangers that surround improper useage of toilets and poor sanitation.
- Toilets are to be dug deep and cemented to prevent erosion and flooding during raining season and contamination of water bodies which also serves as source drinking water of the community.
- Sanitary inspectors and wealth workers should conscientiously do their job to check in discriminate disposal of excreta and poor environmental sanitation.

V. Conclusion

In conclusion, the issue of personal hygiene and sanitation can not be overemphasized in the prevention of cholera outbreak. Therefore, sanitation is highly paramount although cholera may be life-threatening; prevention of the disease is normally straightforward if proper sanitation practices are followed. Effective sanitation practices, if instituted and adhered to; on time, are usually sufficient to stop an epidemic and it reoccurrence.

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A Goal Programming Approach for Multiple Objective Green Supply Chain Managment

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Abstract- Today's green supply chain management (GSCM) has become a protective approach to increase awareness against SCMenvironmental impact. Green strategies have become vital issue for companies to gain environmental sustainability .last year's research shows that the production, transportation, storage and consumption of all these goods related environmental aspect such as emission of greenhouse gases. This paper focuseson the design, planning and controlling in supply chain for transportation and facility. There are several methods for solving multi-objective linear programming (MOLP) models, among them we use the fuzzy programming approaches to solve bi-objective model on the other hand weusetriangular fuzzy number to translate the subjective human perception into a solid crisp value and utilize the fuzzy number approach for uncertain demands .one numerical example is presented to show that our proposed method.

Keywords: green supply chain management, fuzzy demand, co2 emissions, transportation.

GJHSS-B Classification : FOR Code: 969999p

A GOAL PROGRAMMING APPROACH FOR MULTIPLE OBJECTIVE GREEN SUPPLY CHAIN MANAGMENT

Strictly as per the compliance and regulations of:

A Goal Programming Approach for Multiple Objective Green Supply Chain Managment

Mostafa Darjazi [α] & Azadeh Sohrabinejad [σ]

Abstract- Today's green supply chain management (GSCM) has become a protective approach to increase awareness against SCMenvironmental impact. Green strategies have become vital issue for companies to gain environmental sustainability .last year's research shows that the production, transportation, storage and consumption of all these goods related environmental aspect such as emission of greenhouse gases. This paper focuseson the design, planning and controlling in supply chain for transportation and facility. There are several methods for solving multi-objective linear programming (MOLP) models, among them we use the fuzzy programming approaches to solve bi-objective model on the other hand weusetriangular fuzzy number to translate the subjective human perception into a solid crisp value and utilize the fuzzy number approach for uncertain demands .one numerical example is presented to show that our proposed method.

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I. Introduction

Supply chain management system is established by money, component, processes, information flow and the operation in supply chain management and SCM is the most important economic activities in the business. We deal with all aspects of logistic in supply chain management such as transportation, warehouse and inventories, and address are related environmental aspect such as emissions of greenhouse gases, noise that these are the main cause of global warming, air and water pollution , acid rain, etc.

We should balance economics, environmental and social performance to achieve sustainable development is a major business objective of organization due to the challenge of increasing environmental laws and regulations, demanding organizational stake holders pressures and gaining competitive advantage's (Boiral,2006;Lee.et al.,2009;Jabbour and Jabbour ,2009). Recently researches shows environmental challenge, such as green decreases by limited energy and resources and green supply chain (GSC) management is now suggested as an efficient tactics to decrease.

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Operation research (OR) help us to described it as the science, traditionally supply chain management focuses on minimizing the cost of existing processes but todays it is not only profit, in our opinions operation research must consider impact to be more efficient, so OR help us to identify the trade-offs between environmental aspect such as emission of greenhouses costs also OR suggests more efficient of resource and facilities. An important method in this respect is multi objective decision that reduction emission and decreases the benefits of supply chain.

The body of this paper comprises six sections. This paper starts with this introductory section, which provides a general idea about the research topic. Section2 reviews the literature related to a sustainable facility location in green supply chain, practices and performance for sustainable facility location in green supply chain. Section3 addresses the methodology and Section4 presents themultiple objective decision making model. Section5 illustrates the applicability of the model through a numerical. Finally, Section6 relates the conclusions, implications and poses questions for future research, there by fulfilling the purpose of the paper.

II. Literature Review

In order to obtain the greatest benefit from environmental and society, firm must integrate all member in the green supply chain (GSC)(Lee, Kang, Hsu, & Hung,2009).Hence , strategic intercommunity with economically powerful with environmentally socially should be considered within green supply chain(GSC) to reducing lead time and cost ,eliminate wastage, improving quality, so we focus on the structure and discuss the main physical drivers in GSC. We will not different between green logistics and green supply chain management while we mainly focus on transportation; we take a border (supply chain) perspective.

There is a whole stream of research on facility location, which demonstrated by OR, that focuses trade-off the number and location of distribution centers (DCs). Environmental aspects of network supply chain design and facility location recently received considerable attention. Li et al. (2008) with a bi objective attempted to maximize the cost and minimize the emission by mathematical programing methodology to optimize distribution center location center location taking into with consideration transportation cost and

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transportation carbon emission. Mallidis et al.(2010) prop use a multi-objective mixed integer programming model (MIP) to examine how distribution center location (DCs) leasing transportation and warehouse operation so decisions on using dedicated versus shared warehouse and transportation and that model by focus on the transportation operation minimizes the amount of CO2 and PM emissions. Diabat and Simchi-levi (2009) they consider MIP model with a cap on the amount of CO2 that CO2 emission come from warehouse, plants and transports to customers ,finally they show that supply chain cost increase if the cap become tighter. Ramudin and Chaabane (2010) they consider internal and external control mechanisms to propose strategic planning model for supply chain network design. Chaabane et al.(2012) extend the previous approach and introduce a mixed-integer linear programming based on supply chain design that consider life cycle assessment (LCA) ,principles the traditional material balance constraints at each node in the supply chain. Herris et al. (2011) use of simulation model. They consider both logistics cost and CO2 emissions in supply chain optimization. They consider different fright vehicle utilization ratio to account the number of depots the uncertain factor in supply chain make the incorrect estimate. Thus uncertain factor of demand will be considered to support more realistic decision to estimate facility location. Within uncertain patterns, fuzzy numbers will be used to describe this uncertain factor. those fuzzy mathematical programming will be adopted for modeling Wang et al.(2010) Listes and Dekker(2005) they use a stochastic programming model by because of the uncertain demand in the model, As a result this paper shows the product recovery network design in different location. Listes (2007) and Salema et al. (2007) have focused on the uncertainly issues and used specific scenarios to illustrated it. Basic factors that usually create uncertain in the supply chain management are demand, landfilling and recovery rate.

III. Fuzzy Set and Fuzzy Number and Fuzzy Programming Solution Approach

In our real-life we faced many uncertain situations so decision makers cannot use exact value such as exact date and exact number /rate.

Fuzzy logic is an approach to computing based on "degrees of truth" rather than the usual "true or false" (1 or 0) Boolean logic on which the modern computer is based. The idea of fuzzy logic was first advanced by Dr. LotfiZadeh of the University of California at Berkeley in the 1960s. Dr. Zadeh was working on the problem of computer understanding of natural language. Natural language (like most other activities in life and indeed the universe) is not easily translated into the absolute terms of 0 and 1. (Whether everything is ultimately describable in binary terms is a philosophical question worth pursuing, but in practice much data we might want to feed a computer is in some state in between and so we need another way to describe its).Fuzzy logic seems closer to the way our brains work.

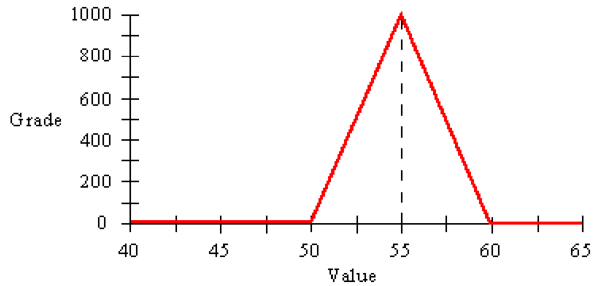
It may help to see fuzzy logic as the way reasoning really works and binary or Boolean logic is simply a special case of it.A fuzzy number is a quantity whose value is imprecise, rather than exact as is the case with "ordinary" (single-valued) numbers.

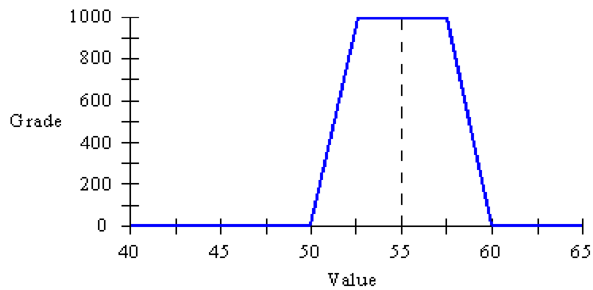
A Fuzzy set $\widetilde{A}$ in X is set of ordered pairs:

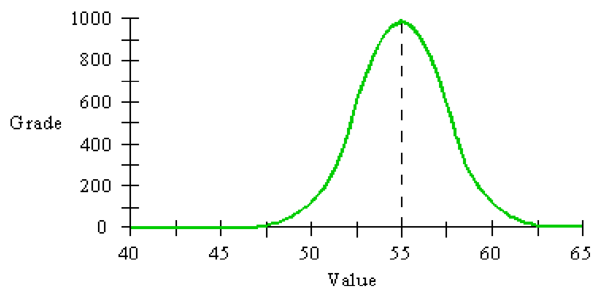
$$\widetilde{A} = \{(x, \mu\widetilde{A}(x) | x \in X\}$$

$\mu\widetilde{A}(x)$ is called the membership function or grade of membership ,often it is appropriate to consider those element of the universe that have nonzero degree of membership in a fuzzy set also membership function can be used in the fuzzy set.

This member in the fuzzy set may have a larger or smaller membership grade, this membership grades are very often represented by real value ranging in the closed interval between 0 and 1. The red curve (top) represents a triangular fuzzy number; the blue curve (middle) shows a trapezoidal fuzzy number; the green curve (bottom) illustrates a bell-shaped fuzzy number. These three functions, known as membership functions, are all convex (the grade starts at zero, rises to a maximum, and then declines to zero again as the domain increases). However, some fuzzy numbers have concave, irregular, or even chaotic membership functions. There is no restriction on the shape of the membership curve.







Nowadays fuzzy programming approach is being applied for solving multi objective linear programming models. There, becausefuzzy approaches is that they able to measure satisfaction of each objective, in Warners (1988)fuzzy and operator and Tiwari et al (1987)weighted additive approach the FGP are introduced. Goal approach is one of the most powerful, multi –objective decision making approaches in practical decision making. However there are two important difficulties when apply GP to the real life. First one is that decision maker to get desirable level of goal mathematically and the second is the need to optimize simultaneously all goal.in this situations, fuzzy set can help us.

Applying fuzzy set theory (Zadeh, 1965) into goal programming has the advantage for decision maker, which can then be qualified by some natural language term. When vague information related to the objectives are present then the problem can be formulated as a fuzzy goal programming problem. Someof the researchers which worked on the decision problem using in the Fuzzy goal programing theory are presented: such as, Narasimhan (1980) was first on that consider the Fuzzy set theory in goal programming. Narasimhan and Rubin (1984), Hannan (1981), Ignizio (1982) and Tiwari et al, (1986, 1987) applied the fuzzy set theory in the goal programing. Ramik (2000), Rao et al. (1988), Wang and Fu (1997), Mohamed (1997), Ohta and Yamaguchi (1996), El-Wahed and Abo-Sinna (2001) and Mohammed (2000).

Sometimes the coefficients are defined as triangular fuzzy numbers; the fuzzy vector is defined as follow

$$\tilde{c} = (c^p + c^m + c^0)$$

There are different approaches to solve the problem;one of the approaches combining conventional parameters fuzzy numbers or fuzzy variable stands for a factor in this case is a definite problem into a lineament problem. A combination of methods, parameters is fuzzy numbers using the following formula:

$$C = \frac{c^p + 4 * c^m + c^0}{6}$$

In science, operations research, different methods to solve multi-objective optimization problems when there are definitive. One of the best ways is to use a phased approach, after application of fuzzy sets is established. Membership functions optimally with any of these methods try to optimize the degree of increase. Therefore, it is first necessary to obtain Optimized membership function.

$Z_1^l = min\ (C^m - C^p)\ X$
$AX \leq b$
$X \geq 0$
$Z_1^u = max\ (C^m - C^p) X$
$AX \leq b$
$X \geq 0$

$$\mu_{z1}(_{z1}) = \begin{cases} 1\ ; & Z_1 \leq Z_1^l \\ \frac{Z_1^u - Z_1}{Z_1^u - Z_1^l}\ ; & Z_1^l \leq Z_1 \leq Z_1^u \\ 0\ ; & Z_1 \leq Z_1^u \end{cases}$$

So that we have:
$Z_1 = (C^m - C^p) X$

Optimized membership functionZ_2 andZ_3 the same way the following objectives are achieved:

$$\mu_{z2}(x) = \begin{cases} 1\ ; & CmX > Z_2^l \\ \frac{CmX - Z_2^l}{Z_2^u - Z_2^l}\ ; & Z_2^l \leq Z_1 \leq Z_1^u \\ 0\ ; & CmX < Z_2^l \end{cases}$$

$$\mu_{z1}(_{z1}) = \begin{cases} 1\ ; & (Cp - Cm)X > Z_3^u \\ \frac{(Cp - Cm)X - Z_3^l}{Z_3^u - Z_3^l}\ ; & Z_3^l \leq (Cp - Cm)X \leq Z_3^u \\ 0\ ; & (Cp - Cm)X < Z_3^l \end{cases}$$

Eventually it becomes a single objective linear programming problem is determined as follows:
Maximize λ

Subject to
$\lambda(Z_1^u - Z_1^l) \leq Z_1^u - (Cm - Cp)X$
$\lambda(Z_2^u - Z_2^l) \leq CmX - Z_2^l$

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$\lambda(Z_3^u - Z_3^l) \leq (Cm - Cp)X - Z_3^l$

$AX \leq b$

$X \geq 0$

$\lambda \in [0,1]$

the main producers of gases are the industrial companies, for green planning the network of supply chain management ,many companies have set voluntary target in term of greenhouse gases emission or set a subject to a new regulation that named capof greenhouse gases emissions ,when the emission carbon dioxide is under the approved emission Scheme carbon dioxide is tradable, also based greenhouse gases emissions reduction target often established by government .the difference between the proposed target and actual target maybe offset by the other things. Also companies that have emission less than the cap target will have sold their credit to make the generate profit.

I this paper we used the upper bound for green supply chain that is variable.

IV. Problem Definition and Modeling

Consider a supply chain network G=(N,A), where N set of node and A set of arc .N composed by the set of supplier ,S, facilities, and customer, C, in this models we consider the CO2 emission in each process of the whole network. Let me define:

a) Parameters

c^P unit of transportation cost in tons per km for product p

$\widetilde{d_k^p}$ The demand of customers for product

s_i^p The supply of supplier for product

d_{ij}^p Transportationdistance for product from supplier i to facility j

d_{jk}^p Transportationdistance for product from facility j to customer k

r_j^p Capacities consumed by handling a unit of products in facility j

f_j Set of cost of facility j

u_j Thehandeling capacity in facility j

l_j^p Handling cost of product p in facility j

w_α CO_2 emissions factor of a facility, in tons per ft^3

w_β CO_2 emissions factor per unit distance, in tons per km

L the lower bound of total produced emission

U the upper bound of total produced emission

b) Decision variable

x_{ij}^p The flow of production p from supplier i to facility j

x_{jk}^p The flow of production p from facilityj to customer k

z_{jl} Facility j with environment protection level l

c) Objective function

$\mathrm{Min} \sum_{p\in P}\sum_{i\in S}\sum_{j\in F} c^p d_{ij}^p x_{ij}^p +$
$\sum_{p\in P}\sum_{j\in J}\sum_{k\in C} c^p d_{jk}^p x_{jk}^p + \sum_{j\in F}\sum_{l\in L} f_{jl} z_{jl} + \sum_{p\in P}\sum_{j\in F} l_j^p \sum_{i\in S} x_{ij}^p$

$\mathrm{Min} \sum_{j\in F}\sum_{p\in P}\sum_{l\in L} w_\alpha z_{jl}^p u_j + \sum_{p\in P}\sum_{i\in S}\sum_{j\in J} w_\beta d_{ij}^p x_{ij}^p +$
$\sum_{p\in P}\sum_{j\in J}\sum_{k\in C} w_\beta d_{jk}^p x_{jk}^p$

$\sum_{i\in S} x_{ij}^p - \sum_{k\in c} x_{jk}^p = 0 \quad \forall j \in F, \forall p \in P \qquad (1)$

$\sum_{j\in F} x_{jk}^p = \widetilde{d_k^p} \qquad \forall k \in C \;,\; \forall p \in P \qquad (2)$

$\sum_{j\in F} x_{ij}^p \leq s_i^p \qquad \forall i \in S \;,\; \forall p \in P \qquad (3)$

$\sum_{i\in S}\sum_{p\in P} r_j^p x_{ij}^p \leq u_j z_{jl} \quad \forall j \in F, \forall l \in L \qquad (4)$

$\sum_{l\in L} z_{jl} \leq 1 \qquad \forall j \in F \qquad (5)$

$L \leq \sum_{j\in F}\sum_{p\in P}\sum_{l\in L} w_\alpha z_{jl}^p u_j + \sum_{p\in P}\sum_{i\in S}\sum_{j\in J} w_\beta d_{ij}^p x_{ij}^p +$
$\sum_{p\in P}\sum_{j\in J}\sum_{k\in C} w_\beta d_{jk}^p x_{jk}^p \leq U, \forall i \in S, \forall j \in F, \forall k \in C, \forall p \in P, \forall l \in L \qquad (6)$

$x_{ij}^p, x_{jk}^p \geq 0 \qquad \forall i \in S, \quad \forall j \in F,$
$\forall k \in C, \quad \forall p \in P, \qquad \forall l \in L \qquad (7)$

$z_{jl} \in \{0,1\} \qquad \forall j \in F \qquad \forall l \in L$

The demand in this model is uncertain so we need to change it to DE fuzzy so in this paper use of under formula:

$$d_j^p = \frac{d(u)_j^p + 4d(m)_j^p + d(l)_j^p}{6} \qquad (8)$$

Above model provide a multi-objective mixed-integer programing for the supply chain network design problem, this model consider environmental investment decision in the supply network design, this model introduce a new category of decision variable to consider environmental issues, and also it can use e specific product or a category of products.

This paper consider two objective functions, first objective measures the total cost first and second part is the transportation cost and the third part is the fixed set up cost and last part is the total handling cost. Second objective measures the total CO2 emission; the first part measures the total emission in the all facilities and the other part measures emission during the arc.

Constraint (1) note that our model there is no inventory stored in each facility. Constraint (2) requires that the all of the fuzzy demands should be satisfied. Constraint (3) shown that each product p flowing out of the supplier I should not exceed the total supply amount of suppliers. constraint (4)state that the total processing handling in facility j should not exceed the capacity if the facility is open(if facility j is open yj=1 and otherwise yj=0).constraint (5) requires that decision makers choose one level for facility j. constraint (6) consider value of emission cap(a carbon-capped supply chain network problem Diabat et al.(2009) .constraint (7) restrict x_{ij}^{p}, x_{jk}^{p} are non-negative and yj are binary integer variable and zj are integer in interval [0,1].

Assumptions:

1. In this model do not consider the bill of material
2. We only consider CO2 emission which is a very popular environment index and can be measured easily.
3. We assume that carbon emission in this model come from two sources:
   a) the facility that the amount of emission is proportional to the volume of this facility
   b) From the transportation vehicle that traveled distance between nodes.
4. We use zjl that means the facility j with l level of environment protection and higher level need more sophisticated equipment or technology is installed.
5. value of emission parameters used according to (a carbon-capped supply chain network problem Diabat et al.(2009))
   $w_\alpha=0.5$
   $w_\beta=0.7$

With this model decision maker should determine:

1. Where to set up facility
2. Which supplier should be selected for each facility
3. Which facility should be selected for each costumer
4. How many/much produced should be transported each supplier to each facility
5. How many/much produced should be transported each supplier to each facility

V. Computational Experiment

We consider 8-node network there are in total 2 supplier, 3facilities and 3 customers in this network with this data and this solved by solver Excel 2010

P=1

CO_2^{CAP}= (L=1600, U=2500)

$\tilde{d}_{C1}^1$ =(23,26,29), $\tilde{d}_{C2}^1$ =(22,26,30) , $\tilde{d}_{C3}^1$ =(35,38,41)

$s_1^1 = 60$, $s_2^1 = 80$

$d_{S1a}^1 = 10, d_{S1b}^1 = 12, d_{S1c}^1 = 22, d_{S2a}^1 = 15,$

$d_{S2b}^1 = 11, d_{S2c}^1 = 21, d_{ab}^1 = 20, d_{ac}^1 = 18,$

$d_{bc}^1 = 16$

$, d_{aC1}^1 = 21, d_{aC2}^1 = 18, d_{aC3}^1 = 14,$

$d_{bC1}^1 = 12, d_{bC2}^1 = 15, d_{bC3}^1 = 11, d_{cC1}^1 = 13,$

$d_{cC2}^1 = 14, d_{cC3}^1 = 17$

C^p=5$

f_a= 2090 , f_b=2260, f_c=2210

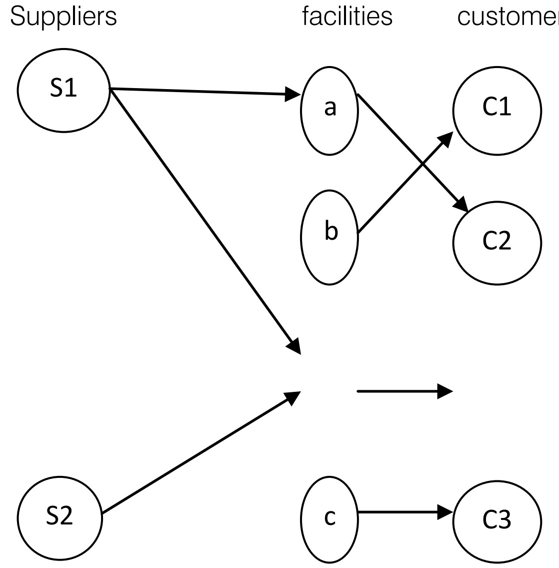
$r_A^1 = 1, r_B^1 = 1, r_C^1 = 1$

$u_A = 60, u_B = 80, u_C = 100$

Result:

Obj_1^u=15520, obj_1^l=23560

Obj_2^u= 1637, obj_2^l=2500



$x_{S1a}^1 = 1, x_{S1c}^1 = 38, x_{S2b}^1 = 51$

$x_{bc}^1 = 32$

$x_{aC2}^1 = 1, x_{bC1}^1 = 26, x_{bC2}^1 = 25, d_{cC3}^1 = 38$

VI. Conclusions

In this paper, we introduce a green supply chain network design model with fuzzy demand which facility location is the main problem the main causes of cost in the green supply chain are the fixed costs to set up a facility, the transportation cost to move goods and the cost of emissions generated on the shipping lanes. The model is a multi-objective model which consists of minimizingtotal cost and environmental influence for solve this model we use of fuzzy method which consider Best and worst objective function value for two objectives then consider membership of them and solve, on the other hand, in this model we consider upper and lower bound for CO2 emission that these bounds depend on the government policy .We use normalized normal Constraint method to solve the model by general EXCEL solver2010. After that, we test the model by a eightnodeexample finally we observethat improving the capacity of the network and increasing the supplyto the facilities can decrease CO2 emission because more distributioncenters be opened to decrease vehicle travel distances.In the network and all of thatminimize the total cost. For The feature our model can be extend with many fuzzy variables with consideration of environmental element in the handling and transportation process, can solvethe uncertain demand with DE fuzzy method, and cansolve it with another solver,You can also considermachine downtime, customer satisfaction, consider the machinery space, consider the different types of machines for transport demand and ... Also be applied to objective functions and constraints.

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