1. INTRODUCTION

1.1 Background

Sustainable development is the philosophy of designing processes, the built environment, and services to comply with the principles of social, economic, and ecological sustainability. The intention of sustainable design is to "eliminate negative environmental impact completely through skillful, sensitive design" (McLennan 2004). Manifestations of sustainable design require renewable resources, impact the environment minimally, and connect people with the natural environment.

India has vast livestock resources. Indian economy depends on livestock as about 20.5 million people depend upon it for their livelihood. Small farm households are strongly dependant on livestock for income as it contributes 16% of their earnings. Two-third of rural community get their livelihood from livestock. Rural economy is benefited by livestock in terms of income, employment, food, social security and it is estimated that about 8.8 % of the Indian population get their employment from it (Vikaspedia). Indian economy is agriculture based contributing 17 % of total GDP of which 25.6% is contributed by livestock sector which comes out to be 4.2% of total GDP. According to 2012 livestock census population the total Bovine population (Cattle, Buffalo, Mithun and Yak) is 299.9 million numbers in 2012 which shows a decline of 1.57% over previous census. The number of milch animals (in-milk and dry) in cows and buffaloes has increased from 111.09 million to 118.59 million, an increase of 6.75% (Ministry of Agriculture, Department of Animal Husbandary 2012).
A cow, after being unproductive is usually sent to slaughterhouse. The main product we get from cow is not just the milk but the cow urine and dung. To prevent unproductive cows being sent to the abattoir, the government of India started the RashtriyaGokul Mission in mid-2014, a national program that involves constructing havens for retired cows (Department of Animal Husbandary dairy & Fisheries). Proceeds from the animal's' bodily waste are intended to pay for their upkeep. A number commercial product has been developed recently from cow dung and cow urine based on the Ayurvedic formulations ranging from medicines, cosmetics and fertilizer, pesticides.

1.1.1 Valorization Of Cow Dung & Cow Urine

Cow is considered as an important animal in all ancient scriptures of India. Five products viz. cow dung, cow urine, milk, curd and ghee obtained from cow are termed as Panchagawya which are advised to women post delivery (Pathak ML and Kumar A 2003). The cow urine, one of the ingredients of 'Panchagawya' is capable of treating many diseases and has been used extensively in ayurvedic preparations since time immemorial as cited in ancient holy texts like CharakaSamhita, SushrutaSamhita, Vridhabhagabhatt, Atharva Veda, Bhavaprakash, RajniGhuntu, Amritasagar, etc (Pathak and Kumar 2003). Several research has been conducted over the past few years and it has been reported that cow urine is capable of curing blood pressure, blockage in arteries, arthritis, diabetes, heart attack, cancer, thyroid, asthma, psoriasis, eczema, prostrate, fits, AIDS, piles, migraine, ulcer, acidity, constipation, gynaecological problems, ear and nose problems and several other diseases. The use of cow urine in India can be traced back to the Vedic and probably pre-Vedic period also. Cow urine as such has been most widely referred, used and venerated animal urine owing to its immense therapeutic specialty. While externally it has been used as lotion, ointments and bath, but, internally it has been used in preparation of oral medications and drinks.. The cow urine not only used against ailments of diseases as therapeutic agents but also have several other uses as in agriculture and sericulture sectors. Cow urine is also reported to have antioxidant and antibacterial properties as quoted in ancient Vedic literature (Edwin et al. 2008).

Cow dung has always been used in purgative context. The ethnographic literature quotes use of diluted mixture of cow dung to clean polluted areas (Korom 2000). A mixture of dung and urine in a ratio of 3:1 contains crude fibre (cellulose with lignin), crude protein, cellulose, hemicellulose. The mixture is also reported to contain 24 different minerals like potassium, sulfur(traces), iron, magnesium,calcium, Cobalt etc. Cow dung is also rich in cellulose, hemicelluloses, and pectin fermenters like bacteria -Bacillus species, corynebacterium species, and lactobacillus species), fungi (aspergillus and trichoderma, protozoa and yeasts - saccharomyces and candida. The green color of cow dung is attributed to the bile pigment biliverdin. Gomeya/cow dung slurry usually a ratio of 1 : 10 or 1:25 is sprinkled over rural,

urban and hospital waste, and oil spillage to degrade them naturally into the basic five elements (Randhawa and Kullar 2011).

1.2 Need Of Study

In recent years, the increase of fossil fuel (crude oil) prices, public awareness regarding energy security, sustainable development, depletion of natural resources, as well as environmental concerns, have encouraged the research community to search for sustainable alternative energy sources. Cattle waste biomass has been identified as one of the potential renewable energy sources to fulfill increasing energy and chemical demands. "Gaushala" is a protective shelter for cattle and it acts as refuge for abandoned cows (Johorey). A facility – "Gaushala" is developed to convert such abundantly available cattle waste into valuable products.

Majority of rural livelihood is dependent on cattle or farm related activities. Hence it is very important to consider socio-economic impacts of such systems in order to develop sustainable products from cow dung & cow urine.

In this study, we have studied a cow shelter as cow dung & cow urine (CDU) biorefinery. The biorefinery includes manufacturing of various cow waste based products ranging from cosmetic, fuel, and fertilizer. The CDU biorefinery is evaluated in terms of environmental, economic and social parameters. Based on these parameters a sustainability index is calculated depicting the overall sustainability of the processes. A Multicriteria Decision Analysis method is adopted to integrate the parameters into one single sustainability index.

1.3 OBJECTIVE OF STUDY

1. To study Environmental, Economical and Social Impact of Goshala
2. To study different goshalas on the basis of their sizes.

2. LITRATURE REIVEW

Eriksson et al. (2016) studiedlca of horse manure. The interest in horse manure undergoing anaerobic digestion and thereby producing biogas has increased with an increasing interest in biogas as a renewable fuel. This study aims to highlight the environmental impact of different treatment options for horse manure from a system perspective.

Augustine and George (2007) studied environmental impacts of cocoa production and processing in ghana. Life cycle assessment approach. It included the extraction of raw materials (e.g. Fossil fuels, minerals), the production of farming inputs (e.g. Fertilizers and pesticides) and all agricultural operations in the field (e.g. Tillage, fertilizer and pesticides application, harvest, etc.). Transportation of beans to processing factory and industrial processing of the beans into cocoa butter, liquor, cake and powder were also included.

Monika and Tadeusz (2013) studied life cycle assessment of fertilizers: a review the paper describes life cycle assessment of mineral fertilizers. On the basis of results provided by life cycle assessment, it can be concluded that an effective strategy for protecting the environment against the harmful effects of fertilizers is to attempt to 'seal' the nutrient cycle on a global, regional, and local scale.

Annettek and Caroline (2009) compared the environmental footprints of home-care and personal-hygiene products.The relevance of different life-cycle phases an in-depth life-cycle assessment of nine home-care and personal-hygiene products was conducted to determine the ecological relevance of different life-cycle phases and compare the environmental profiles of products serving equal applications.

Punam et al., (2014) studied environmental footprint of cooking fuels. A life cycle assessment of ten fuel sources used in indian households the aim of this paper is to evaluate and compare the environmental performance of various cooking fuel options, namely lpg (ng), lpg (co), kerosene, coal, electricity, firewood, crop residue, dung cake, charcoal, and biogas, in the indian context.

The purpose of this study is to find environmentally suitable alternatives to lpg and kerosene for rural and urban areas of the country.

Komakech et al., (2016) studied environmental impact from vermicomposting of organic waste in kampala, uganda vermicomposting is one of the methods proposed to address this challenge. This study investigated the environmental performance of the vermicompost system by measuring the gaseous emissions generated from the system. In addition, the vermicompost system was compared with other manure management systems currently in use, using life cycle assessment (lca) methodology.

Brianking(1993) social impacts of tourism: host perceptions this study investigates the perceptions of the residents of nadi, fiji, towards the impacts of tourism. A survey of 199 households revealed that residents (most of whom were dependent on the industry for their livelihood)supported the current magnitude of tourism and favored its expansion.

3. GOSHALA AS BIOREFINERY

Generally a cow shelter is inhabited by cows ranging from 100 to 5000 cows, each producing about 10 kg of dung and 5 ltr of urine per day. This huge amount of waste generated daily can be converted into energy & value added products like biochemicals, fertilizers, pesticides and even medicines and cosmetics.

The products of the cow based biorefinery can be broadly classified into three main categories.

- Energy and fuels
- Medicines and FMCG
- Agro-products

Here we studied three Goshala's which are different on their sizes.

- Goveda, Wardha, Maharashtra. Inhabited 100 local breed Gaolaou its low milking breed but use for transportation.
- Swapnpurti, Sindhpuri, Th. Tumsar, Dist. Bhandara, Maharashtra. Here we found fifty cows which are high milking breed, the main focus is milk, and as Swapnpurti is not manufacturing medicine from cow dung and cow urine, so they have stall feeding.
- GoVigyanAnusandhan Kendra (GVAK), located at Deolapar, Nagpur, Maharashtra. Contain 500 + cows in shelter.

This goshala's are different on the basis of their sizes that is number of cattle they are rearing. As cattle are main source of raw material for CDU biorefinery.

We divided study in two different part one is data collection of Goveda and Swapnpurti and sustainability assessment of GVAK.

Goveda and Swapnpurti are not maintaining record officially, and there is no standard operation practice in them as compare to GVAK. Sustainability assessment is done using three criteria economic, social and environmental. That is how Goshala is economically, socially and environmentally sustainable or in other what impact goshala made on society through this three criteria.

3.1 GOVEDA, WARDHA - A CASE STUDY

Goveda located at Aamgoan, Wardha , India been considered as second system for study. Figure 1.1 shows the geographical location of Goveda. This year they shift on new location near Jamani Sugar Mill. So there is no permanent construction available which show in figure 1.1 is. Cows are free grazing in jungle, so milk is highly medicinal in nature.

Figure 3.1: Geographical location of Goveda (20°52'56"N, 78°34'06") (Source : Google Earth)

Presently 100 cattle are inhabited in Goveda campus. Near about 60 of cattle are providing milk at a time remaining are dry during that period. The work in Goveda are done by proprietor nandugawande and his family, they has two permanent cow rearing. All the product are manufactured by NandKishorGawande by himself with the help of his wife.

The cow urine (CU) and cow dung (CD) are used from the non milking and non pregnantcattles. There are 6 product Gveda manufacturing in three path which are shown in table 3.1.

Table:-3.1 Shows different product produce in Goveda, wardha.

Path	**Product**
Milk	Khoya
	Sweet
	Ghee
	Nasya
Cow Urine	Cow Urine Ark (CUA)
Cow Dung	Decorative Craft

There are three raw material to produce different product, from milk they produce khoya, sweet, ghee and nasya. Cow urine ark is obtain from the cow urine. cow dung are used to make decorative pieces like momentos.

Khoya:-Khoya is a milk product made by continuously evaporating the milk in jacketed vessel until it is reduced to a solid granular form. This evaporated milk solids is then used in various food preparations especially in making sweets. Per day goveda produce 12 kg of khoya from 50 litre of milk. They use cow dung cake as a source of fuel. Figure 3.2 Shows making of khoya in jacketed vessel. Figure 3.3Shows packed khoya of half kg

Figure 3.2: Making of khoya

Figure 3.3: Packed khoya

Sweet:-This method is basically identical to that of burfi preparation wherein a mixture of khoa and sugar is heated at low fire with sufficient working and kneading till desired texture is attained. Peda is normally made into round balls of about 20-25 g size by rolling between the palms.Sweet has more market demand and it is famous as “Deshi Gaichya Dudhacha Peda”

Figure 3.4: Sweet packed in 250 gm packet.

Ghee:-The Ghee is prepared b fermenting whole milk to curd, churning the curd to butter and boiling down the latter to ghee. Ghee is the richest source of animal fat in vegetarian diet.

Nasya:-It is same like ghee with medicinal properties, they are packed in small size and use as nasya, which is aayurvedic preparation helpful in many diseases of brain.

Figure 3.5: Nasya packed in 20ml pack

Figure 3.6: CUA pack in 200ml pack.

CUA:-is manufactured from the fresh cow urine. CU is distilled and the top product of distillation is packed as CUA which is the end product.Pack of 200ml shown in figure 3.6.

3.1.1 ECONOMICAL DATA OF GOVEDA

As the breed goveda has is Gaolao, a breed of western and middle part of India and known for its agility. The breed is also known as “Arvi” and “Gaulgani”. The breed resembles Ongole breed, except that it is lighter. The coat colour is blackish white in males and white in females. Males are generally grey over the neck. Horns are short, stumpy and curved slightly backward. Head is markedly long and taper towards muzzle. Forehead recedes at the top giving a slightly convex appearance. Bullocks are trained for moving fast.

Figure 3.7: Gaolao Breed of Cow.

The milk yield is low with an average of 604 kg per lactation with 4.32% fat (ranges between 470 to 725 kg per lactation).So they have restirctuion in production of milk product, and due to less manpower they can’t fully use cow urine and cow dung. Also goveda is not focusing more on profit they are focusing to srve “Goumata”. So they only have low milking per local breed Gaolao Table 3.2shows the average selling data per month and price of six product in three financial year. Data of decorative item not obtain at it start from this year only.

Table 3.2:Average selling per month of six product in three financial year

Product / Year	**Price**	**2017-2018**	**2017-2016**	**2016-2015**
Khoya (in kg)	380 (per kg)	360	240	150
Sweet (in kg)	400 (per kg)	240	150	90
Ghee(in kg)	2000 (per kg)	15	9	5
Nasya (Unit)	50 (per Unit)	200	170	120
CUA (Unit)	300 (per Unit)	150	100	40
Decorative Craft	500 (per Unit)	NA	-	-

They are main focusing on milk product because market is available nearby goshala and there is huge demand for that, and sweet is obtain from the khoya which not sold, so nothing go west and sweet is not perishable item so it can transport in other district too.

3.2 SWAPNPURTI, SINDHPURI, TH. TUMSAR, DIST. BHANDARA: A CASE STUDY

Swapnpurti located at Sindhpuri, Th. Tumsar, Bhandara, India been considered as third system for study. It is started from 2015 and slowly increasing their product range. Figure 3.8 shows the geographical location of Swapnpurti.

Figure 3.8 Geographical location of Swapnpurti (21°28'53"N, 79°51'27") (Source : Google Earth)

Presently 50 cattle are inhabited in Swapnpurti campus. Near about half of cattle are providing milk at one time remaining are dry during that period. There are total 15 worker work in swapnpurti, four of them are used for cow rearing they are full time live in campus only. Four labour who are from village are working in production department for making different product. One manager they have for proper working of goshala operation and one driver for transport. Five of men's are use for marketing in Chandrpur, Bhandara and Nagpur district.

The product are classified in three path cow urine based, Cow dung based, and milk as a product Swapnpurti sold earth worm as a product too, which is by product of vermicompost. They are

classified into 9 product swapnpurtimanufacturings which are shown in table xxx. Gonyle, and pest repellent are manufactured from cow urine. Source of mosquito coil, tooth powder, scented sticks, face pack and vermicompost is cow dung. Milk is sold in Tumsar city in retail, so they get maximum profit and direct customer access.

Swapnpurti is full commercial goshala run by PawanKatnkar a chemical engineer by education, he use his study to manufacture different product. He take more effort in marketing, selling and branding the product. He specially has team of five people for marketing, which is unique initiative swapnpurti do than goveda and GVAK. Which help them to improve there economics and market penetration in nearby cities, now they are planning to expand business in all over Maharashtra.

Table 3.3 shows the 9 different product swapnpurti manufactures in four different path.

Table 3.3: Swapnpurtiproduct classified in four path

Path	**Product**
Cow Urine	Gonyle
	Pest Repellent
Cow Dung	Mosquito Coil
	Tooth Powder
	Scented Sticks
	Face pack
	Vermicompost
Milk	Milk
Earth Worms	Earth Worms

Gonyle:-It is a product which replace phenyl from home, For swapnpurti it is only highly demanding product. It uses cow urine as antibacterial agent. It contain 750 ml pine oil, 250 ml emulisfire, 200 ml Cow urine and 10 liter of water, they mix in the agitator for 15 minute. Gonyle is highly selling and one of high margin product product of goshala.

Figure 3.9: Gonyle pack in 1 liter pack

Pest Repellent: - Cow urine is main raw material for pest repellent due to its repelling property. 15 liter of Cow urine is mixed with neem leaves and keep for fermentation for 21 days. Then boil it until it reach one forth and then pack as per requirement.

Figure 3.10: Earthen pot for fermentation

Figure 3.11: Vessel use for boiling.

Mosquito coil:-It is made from the dough of cow dung which contain many herbal product who are used as essence and have property of repelling mosquitoes. It is made using machine showing in figure it is totally run manually, by hand pressing at one time you get one coil.

Figure 3.12: Mosquito coil making machine.

Tooth powder:-It is new product Swapnpurti launch this yearit easily accepted in there regular market very easily. Made from CD its is burned in absence of air then the char is pulverized and pass for the screening through cloth then its packed in bottle of 60 gm shows in figure 3.13.

Figure 3.13: Tooth powder pack of 60gm.

Scented Sticks:- "Dhoop" (scented sticks) are manufactured using DC where DC is pulverised and powder is mixed with biogas slurry to form dough. Scented sticks are made by using dhoop making machine shown in figure 3.15 and 3.16, operated manually shown in figure xxx.

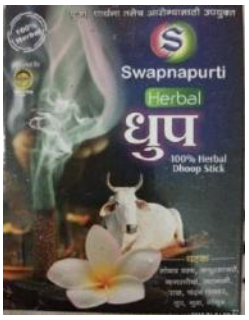

Figure 3.14: Packet of dhoop

Figure 3.15:Front view of dhoop machine

Figure 3.16:Top view of dhoop machine

Face pack:- Facepack ("Ubtan") is manufactured from using raw cow dung. Raw cow dung is mixed with ocher ("geru") and fullers earth. The mixture is agitated manually and sun dried. The dried powder is pulverised further to obtain a uniform free flowing powder which is used as Facepack.

Vermicompost:- Is processed from raw cow dung which is treated for 15 days to remove its heat then keep for 28 days in bed with earth worms to get Vermicomopst. Only we have to take care of light and humidity for proper product rest of the thing is handel by earth worms.

3.2.1 Economical data of Swapnpurti

Table 3.4: The price and average selling of nine product in the two financial year of 2017-2018 and 2016-2017 per month.

Product / Year	**Price**	**2017-2018**	**2016-2017**
Gonyle(Unit)	70	1000	200
Face pack (Unit)	25	200	50
Mosquito Coil (Unit)	35	150	-
Tooth Powder (Unit)	24	50	-
Scented Sticks (Unit)	15	600	200
Pest Repellent (Unit)	250	100	20
Vermicompost (tons)	5000	10	4
Earth Worms (in kg)	500	70	20
Milk (in liters)	40	200	60

Due to great marketing team Swapnpurtigoshala is doing exponential growth in market, therefore they achieve economical sustainability in less amount of time. Last year their turn over per month is more than 200 thousand rupees.

They go through the regular training in various institutes to increase the range of product, the training of CD and CU based product is get through the GVAK, for chemical based product such as gonyle they get training in Mahatma Gandhi Institute of Rural Industrilization.

3.3 GOVIGYAN ANUSANDHAN KENDRA (GVAK) - A CASE STUDY

Go-VigyanAnusandhan Kendra (GVAK) located at Deolapar, Nagpur , India (Go-VigyanAnusandhan Kendra) has been considered as one of the system for study. Figure 1 shows the geographical location of GVAK.

Figure 3.17 Geographical location of GVAK (21°35'25.72N, 79°22'25.16") (Source : Google Earth)

Presently 550 cattle are inhabited in GVAK campus. Near about 500 cattle are non-milch types. Around 53 different categories of products ranging from medicines, pesticides to cosmetic are manufactured at the facility. Separate distribution centers are setup to sell these products. GVAK also has a cow based organic farming project on about 65 acres of land where crops like rice, wheat are cultivated. The daily energy requirement is partially sourced through in-house biogas generation unit and cow dung cake. In economic aspects, GVAK monthly turnover is around Rs. 1.5 million providing employment directly or indirectly to nearly 100 villagers. GVAK also gives training to farmers and common people to help them starting their own enterprises. GVAK has been giving training to farmers on organic farming. The study of GVAK is shown in the next chapter where we provide economical social and environmental data.

4 SUSTAINABILITY ASSESSMENTS OF GVAK

We choose GVAK only for sustainability assessment because its data is only available on paper for study, other two goshala's are not maintaining record. Out of the 53 different types of products manufactured at GVAK, 11 products viz. dung cake, tooth powder, "dhoop" (scented sticks), facepack, massage oil, bathing soap, medicinal soap, cow urine distillate (CUD), "Aasav", shampoo and pest repellent, are selected for sustainability assessment owning to its relatively high production volumes.

Dung cake:- Dung cakes (DC) are used as a source of energy in the nearby villages and at GVAK facility as well. DCs are also used as a raw material for different products of GVAK. DC is made manually by moulding process. The wet moulded shape is sun dried to obtain DC. Toothpowder is manufactured by combusting DC in absence of air.

Tooth powder:- It is made from DC its is burned in absence of air as shown in figure 4.1 then the char is pulverized and after screening through cloth its packed in bottle of 60 gm.

Figure 4.1: Furnace to burned DC.

Figure 4.2: 60gm pack of tooth powder

Scented sticks:- "Dhoop" (scented sticks) are manufactured using DC where DC is pulverized and powder is mixed with biogas slurry to form dough. Scented sticks are made by injection molding process operated manually. They have two type one is simple and one with chandan powder.

Facepack:-Facepack ("Ubtan") is manufactured from using raw cow dung. Raw cow dung is mixed with ocher ("geru") and fullers earth. The mixture is agitated manually and sun dried. The

dried powder is pulverized further to obtain a uniform free flowing powder which is used as Facepack.

Figure 4.3: Kandhenu facepack

Figure 4.4: Massage oil

Massage oil:-Is manufactured using cow dung slurry that is mixed with medicinal oil and then it is filtered. The filtered solution is then concentrated to half its volume by heating it for 4-5 days. Wood is primary source of heating sourced from nearby jungle. The bottle of massage oil is shown in figure 4.4.

Bathing soap:-The manufacturing process for bathing soap is similar to that of Facepack. The mixture of cow dung, ocher and fullers earth is again mixed with medicinal oil to form a dough. This dough is then moulded in shape of bathing soap and packed.

Figure 4.5: Bathing soap

Cow urine distillate (CUA):- Is manufactured from the fresh cow urine. CU is distilled and the top product of distillation is packed as CUA which is the end product. Its mostly done in earthen pot coated with cement to increase life time of pot.

Figure 4.6: Distillation assembly

Figure 4.7: Cow urine ark

Aasav:- "Medicinal Liquor"(Aasav) is manufactured from CU. Cow urine is mixed with medicinal herb and fermented for 21 days in a fermenter made of china clay. The mother liquor obtained after fermentation is then filtered and packed.

Shampoo:-Is made from the CU by heating it in the presence of herbs like "ritha" and "shikekai" for one day. It contain CU 10 liter, ritha 1.5kg, shikekai 500 gm, ajiwain stave 75 gm and camphor 50gm. Soak ritha and shikekai for one day in CU. Next day boiled it to become half of the solution, then after cooling add ajwainstava and camphor and then pass it for packing.

Pest repellent:- The mixture of CU, neem and garlic paste is fermented for 21 days and sold as pest repellent. The filtered fermented product is then concentrated to one fourth of its original volume in a copper vessel. The concentrated solution is packed and used as pest repellent.

GVAK is evaluated based on the three parameters viz. economic, environmental and social.

4.1 ECONOMIC PARAMETER

The economic criterion has only one indicator: gross profit earned. This criterion evaluates the profit earned per kg of CDU bio refinery.

Table 4.1: Selling of eleven product in the financial year of 2017-2018

Product / Month	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
Dung Cake	560	620	598	600	588	600	598	578	630	578	625	610
Tooth Powder	1790	1517	1790	1650	1600	1550	1500	2612	700	2100	1385	2110
Scented Sticks	550	1628	1160	50	775		56	698	1323	1322	300	500
Facepack	2700		1100	1930	1025	100	1700	1600	1600	1300	100	2500
Massage Oil	90		176	215	50		464	325	445	470	374	20
Bathing Soap	3200	6400	9850	3200	4750	2800	3300	4750	2800	5450	480	4500
CUA	2294	2635	1405	3754	3571	3305	3749	4909	5071	2066	3080	3123
Aasav	50	422	158	369	380	139	235	679	516	336	762	219
Shampoo	48	95				234		315			20	544
Pest repellent	60	55	65	65	45	50	55	70	60	70	60	72
Vermicompost	30	25	40	20	15	8	7	12	25	30	16	14

Table 4.2:Selling of eleven product in the financial year of 2016-2017

Product/ Month	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**

Dung Cake	520	472	450	489	500	490	468	500	482	500	470	525
Tooth Powder	1190	1417	1700	2200	1400	1750	1300	2862	600	2100	1200	2100
Scented Sticks	500	1628	960		500			300	1323	1518	300	500
Facepack	2400		1550	1900			1600	1500	1500	1300		2400
Massage Oil				100			623	455	244		696	
Bathing soap	2800	6600	9800	3000	4500	2700	5400	3000	900	5100		
CUA	2223	2502	2568	3939	3622	3025	3663	4750	2151	2476	3120	2886
Aasav		266	158		299	405	139		679	502	646	169
Shampoo		103				204		265		283		510
Pest repelent	40	55	60	56	52	47	52	46	57	50	55	58
Vermicopost	30	15	14	8	7	25	12	16	20	9	7	15

Table 4.3: Selling of eleven product in the financial year of 2015-2016

Product/ Month	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**

Cung Cake	510	425	480	452	457	470	452	435	425	440	430	444
Tooth Powder	1170	1070	445	900	1493	1800	900	600	1800	2300	600	850
Scented Sticks	600	540	60	0	0	940	540	0	0	0	0	0
Facepack	0	600	100	1000	300	1100	900	0	1500	0	0	0
Massage Oil	0	277	50	0	287	456	216	830	501	747	286	214
Bathing soap	3000	990	5550	3000	900	4500	4200	3900	6000	1600	0	2100
CUA	2416	1752	1488	2578	2922	3991	1664	3620	3051	3489	3114	1897
Aasav	205	376	0	571	107	0	322	125	525	160	584	122
Shampoo	429	0	0	69	426	0	501	26	50	0	0	126
Pest Repelent	40	44	52	80	45	62	40	49	30	25	35	45
Vermicmpost	12	15	16	8	9	5	6	12	14	12	8	9

GVAK doesn't have any special sell team but due to their long presence in market and one of the early production oriented goshala, it has large market penetration than other two goshala. They have their distributor across the country who sells their product as per commission basis.

There is no such strategy GVAK follow in selling it just happen on market demand at that particular month, so we can't predict the any relationship in selling. But it seen from averaging the sales of each year for a month then it is found that there is linear increment of 10% per year. This is sign of normal business growth.

The average sales data of units sold per month of GVAK for three years (2015-2016; 2016-2017; 2017-2018) is presented in Table 4.4.

Table 4.4 Average number of units sold per month for products for three years.

Product / Year	**Price(Rs)**	**17-18**	**16-17**	**15-16**
Dung Cake	2	598	488	452
Tooth Powder	30	1692	1652	1161
Scented Sticks	20	697	627	223
Facepack	20	1305	1179	458
Massage Oil	90	219	176	322
Bathing Soap	25	4290	3650	2978
CUA	70	3247	3077	2665
Aasav	110	355	272	258
Shampoo	125	105	114	136
Pest repellent	250	60	52	45
Vermcompost	9	37	14	19

Cow dung and cow urine (CDU) used per unit of final product is calculated from the standard manufacturing method adopted by GVAK. The raw material cost (RMC) for products are calculated which includes raw material cost and packaging cost. All the relevant data is sourced

from GVAK and shown in table 4.5. The gross profit on the sale of products is calculated per unit mass of CDU.

Table 4.5: Shows RMC for product of CD.

Path	Product	Quantity Produce Per Kg Cow Dung	Raw Material Required	Quantity of raw material per Kg	Cost of raw material in Rs per kg
Energy	Biogas	0.24m3	Cow Dung	1	1
			Water	1	1
	Dung Cake	8 No.	Cow Dung	1	1
Medicine And FMCG	Tooth Powder	0.6096	Cow Dung Char	1	16
			Rock salt	0.16	4
			Kapoor	0.02	300
			Water	0.25	10
			clove Oil	0.027	500
			alum powder	0.067	28
	Scented Sticks	2.71Kg	Broken Rice	0.125	20
			Raal	0.05	270
			Jaggery	0.05	50
			Ghee	0.125	1000
			Gum(Dink)	0.05	285
			Cow urine	0.375	10
			Cow Dung Cake Powder	1	
			Wood Dust	0.25	25
			Biogas Slurry	2.5	1
	Facepack	2.2634 kg	Cow Dung Cake Powder	1	10
			Multani Mitti	2.56	10
			Gairik	0.22	5
	Massage oil	1.7675 kg	Murchit oil	0.5	127
			Cow dung Water	1	10
			Ajwain satv	0.005	540
			kapoor	0.0125	300
			Cow Urine	0.25	10
	Bathing soap	2.323 kg	Dung Cake Powder	1	10
			Multani mitti	2.56	10
			Gairik	0.22	5
			Nim Leaves	0.1	28
Agro Product	Vermicompost	0.75 kg	Cow Dung	1	2

Table 4.6: Shows RMC for product of CU

Path	Product	Quantity Produce Per Kg Cow Urine	Raw Material Required	Quantity Of Raw Material	Quantity of raw material per Kg	Cost of raw material in Rs per kg
Medicine And FMCG	Distilate	0.5	Cow Urine	1	20	
	Aasav	8	Cow Urine	8	20	160
			Chitrak Mul	0.025	180	4.5
			Black Paper	0.025	870	21.75
			Pipali	0.025	780	19.5
			Sonth	0.025	260	6.5
			Shahad	0.3125	500	156.25
			Ghatki Pushp	0.03125	680	21.25
	Shampoo	5	Cow Urine	10	20	200
			Ritha	0.15	70	10.5
			Shikekai	0.05	138	6.9
			Ajwain Satv	0.0075	540	4.05
			Kapoor	0.005	300	1.5
Agroproducts	Pesticide	2.5	Gomutra	10	10	100
			Nim Leaves	0.25	28	7

Table 4.7 and Table 4.8 present gross profit earned per kg of CD and per liter of CU respectively used for making useful products. It is found that the profit obtain in massage oil is maximum and vermicompost gives minimum profit. But amount of vermicompost sell is maximum and massage oil is not sold in maximum number.

Table 4.7 Gross profit for products per kg of CD

Product	**CD used Kg/Unit *10-3**	**cost of production Rs/Unit**	**Selling price Rs/Unit**	**Gross Profit earned Rs/Kg**
Tooth powder	250	6.95	30	92.20
Scented Sticks	16.67	2.87	25	1327.53
Facepack	37	1.96	20	487.57
Massage oil	28.5	6.5	90	2929.82
Bathing Soap	66.8	2.33	25	339.37

Table 4.8 Gross profit for products per liter of CU

Product	**CU consumption (liter/unit)**	**cost of production (Rs/liter of CU)**	**Selling price (Rs/Unit)**	**Gross Profit earned (Rs/liter of CU)**
CUA	0.4	12.65	70	143.37
Aasav	0.2	45.3	110	323.5
Shampoo	0.2	23	125	510
Pest Repellant	4	47.95	350	75.51

The total amount of CDU used for production is calculated based on the material balance calculation across every product and the sales data obtained.

A maximum profit is observed for product "massage oil" as the amount of CU required is less and commanding a very high profit margins. Minimum profit is observed for vermicompost as the product is sold at a relatively low cost. It is interesting to note that though massage oil has high profit margins yet the market demand for this product is very less compared to vermi compost. In addition, the process of production of vermicompost is very simple compared to massage oil.

Table 4.9 Maximum and Minimum profit obtained from all products

Indicator	Present profit (Rs)	Maximum Profit (Rs.)	Minimum Profit (Rs.)
Profit	667084.67	29132220.70	235930

4.2 ENVIRONMENTAL PARAMETER

This criterion assesses environmental impacts and is divided into two sub-criteria:

i) Energy used
ii) Product replacement potential

The main source of fuel for GVAK is waste wood sourced from nearby jungle. In addition other raw materials like ocher, fuller's earth, herbs are locally sourced. Thus due to absence of the inventory data, it becomes difficult to perform life cycle assessment as prescribed in ISO 14040:2006 (International Standardization Organization 2006).

The primary source of energy at GVAK is wood burning which is considered as carbon neutral process as biogenic carbon dioxide is emitted. Energy obtained from LPG and cow dung cakes are negligible compared to wood.

The products obtained from GVAK are of same standards as that of commercially available options.

Vermicompost amounts to significant amount of sales volumes compared to other products. Also vermicompost directly replaces urea in the ratio of 2:1. Hence a direct reduction in

environmental impact can be observed with the use of vermicompost instead of urea. The sub criteria "Product replacement potential" deals with the ability of the product to replace the synthetically manufactured commercial product, in this case Vermicompost.

Though it is obvious that methane emission during composting process would add up to overall emission however the overall GWP of the product is less than a synthetically manufactured product like Urea. The total emission in terms of CO_2 equivalent is reported to be 0.240 and 0.401 per kg of manure produced from active and passive aeration treatment (Hao et al. 2001) while for urea the emission is reported to be 1840 kg CO_2 equivalent/ kg of urea (Wood and Cowie 2004). Vermicompost can replace the urea completely in some cases but commonly we choose product replacement value of vermicompost is 0.4 as per survey of farmer/ input got from farmers.

4.3 SOCIAL PARAMETER

Social impact assessment is performed to evaluate, monitor and act on the social ramification of a particular product, process or policy. The primary objective of such evaluation is to achieve a more comprehensive sustainable human environment. Research interest in Social Life cycle Assessment (SLCA) has been picking up recently with application in fluctuated territories like design, industrial management, tourism and so forth. With no concurred strategy available for choice & calculation of pointers, the participatory approach is followed for social indicator wherein the supposition of CDU biorefinery provides employment to nearby people of GVAK. The social criterion is evaluated based on four indicators viz. financial status, health satisfaction, prerequisite skills (training requirement) and social status. As there is no specific task assigned to one labor to one process in GVAK, we have considered social impact of all product lines of GVAK. The quaternaries is shown in annexure A

Financial Status: The indicator deals with improvement in financial status of the employees working for GVAK. The employees (both men and women) are generally villagers in nearby areas. The indicator is important as the employment is generated for rural people who have limited employment opportunities.

Health satisfaction: This indicator deals with health impacts on the employees working in GVAK. There are no reported health issues of the employees. As a part of health awareness GVAK undertakes medical checkup camps to ensure health safety of its employees.

Prerequisite skill requirement: This indicator deals in the need of prerequisite skill for joining as a employee to GVAK. There are no such mandatory requirements as prescribed by GVAK. This indicator is strictly restricted to site labors and daily wages employees. The training pertaining to specific equipment/ process is provided by GVAK management.

Social stature: The indicator deals with the social stature of the employees working in GVAK. The social stature of employees includes perception of society towards the employee.

Survey was carried out among the workers of GVAK working in different manufacturing departments. From the survey, satisfaction level of workers is determined. Questionnaire for survey is designed to evaluate the indicators on a scale of 0 to 1. The survey was conducted among 70 workers working in GVAK. The overall social impact is calculated based on the results obtained from the survey. The details of the questionnaire are a part of the supplementary data.

4.4 SUSTAINABILITY ASSESSMENT USING MIVES

MIVES (ModeloIntegrado de Valor para EstructurasSostenibles) is a unique MCDA method. MIVES is based on identifying different criteria, which are further divided into sub-criteria. These criteria are quantified using indicators. To quantify the indicators MIVES uses concept of value function (Alarcon et al., 2011). MIVES gives the most sustainable alternative based on assigned relative weight of chosen criteria. For the present study three criteria were identified which are economic, environmental and social. The economic criterion was evaluated using profit as an indicator, environmental criteria was evaluated using results of LCA. The social criterion is estimated by getting expert opinions and surveys. A sustainability index is calculated based on the value functions of all indicators and the relative weights assigned to them.

A working group comprising researchers from three Spanish universities and institutes (UPC, UPV, and Labein-Tecnalia) has developed“MIVES approach.” This was initially applied to sustainability studies and industrial buildings. This approach expresses all indicators and criteria in a standard unit

by which a comparison of all alternatives is made on the same platform. This standardization is achieved using a scale of preference, or the degree to which a certain desired outcome is satisfied (Alarcon et al., 2011). This work uses this approach and incorporates various economic, environmental and social factors for alternatives under consideration, with simplified life cycle assessment (LCA) considering all indexes.

The assessment methodology involves the following steps:

1. Design and formulate a problem statement and recognize the parameters affecting the system (Aguado et al., 2012).
2. Present all parameters to be considered for assessment in hierarchical format. Finding the maximum and minimum values of all the parameters under consideration for alternatives. This includes literature survey of all previous studies, published facts, and the prescribed acceptable limits of a certain parameter.
3. Assigning proper weightage to every parameter based on the role of parameter in the entire system and the assessment.
4. Define the tendency and shape of the curve, that is, the change in value function of the parameter for alternatives from minimum satisfaction to maximum satisfaction value.
5. Define the points corresponding to the minimum (Xmin, value 0) and maximum (Xmax, value 1) satisfaction.
6. Define mathematical expression for value function.
7. Evaluating the SI based on value functions and relative weights of the parameters

A convex function is used when there is hardly any change in satisfaction values for small changes in the point having minimum satisfaction. This type of function is used when maximum satisfaction is highly desired. In general, convex function is used for economic and environmental parameters to ensure the points are near the maximum satisfaction value (Alarcon et al., 2011). Therefore, this function is used for parameters such as raw material cost, resource use, GWP.

A concave function is used when a small change in the point generating minimum satisfaction is highly desired. Concave function is used when moving away from the point of minimum satisfaction is more important than gaining maximum satisfaction (Alarcon et al.,

2011). Hence a concave function is used for parameters such as cultural acceptance, skilled labor, Fig. 4.8. Shows different types of functions.

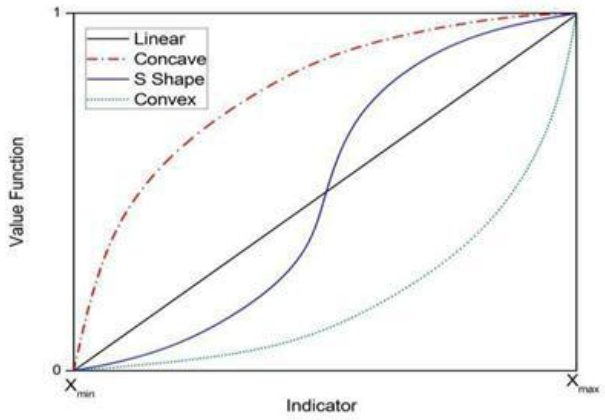

Fig. 4.8. Types of curves used in the MIVES

The parameters, tendency, and shape of the value function for each indicator are determined from international guidelines, scientific literature, LCA results, surveys, etc. In the next step, the value functions are calculated based on the general exponential Eq.

$$V = A + B[1 - e^{-K_i(\frac{|X_{ind} - X_{min}|}{C_i})^{P_i}}] \quad \text{.....(1)}$$

Generally A=0, Value of P_i decides the shape of curve (Concave, convex, linear, or S shaped)

X_{ind} is the value which generates value function V_i,

C_i establishes abscissa value for points where curvature changes its direction,

K_i value defines response value to C_i,

B value limits the function in range 0 to 1 obtained by Eq. (2). The sets of indicator values ($V_i(x_i)$) that are between 0 and 1, according to the satisfaction range, is generated by Eq. (1).

$$B = \frac{1}{1 - e^{-K_i\left(\frac{|X_{max} - X_{min}|}{C_i}\right)^{P_i}}}$$

It is seen from equation 1 that the shape of value function is strongly dependant on the values of C, K and P. Table 4.9 shows a characteristic values of C,K and P for construction of different type of value function. If the shape of the value function is not clear the values of C,K and P can be defined by individuals to obtain a set of function for same indicator. A mean of value function for different measurements is calculated. The C, K and P can be then estimated through a minimum square approach (Alarcon et al., 2011). The C,K and P values are assumed based on previous work (Amin Hosseini et al., 2016).

Table 4.9: Values of C, K and P for different curves

Increasing Function			
Function	C	K	P
Linear	$C \approx X_{min}$	≈0	≈1
Convex	$X_{min} + \frac{X_{max} - X_{min}}{2} < C < X_{min}$	< 0.5	> 1
Concave	$X_{min} < C < X_{min} + \frac{X_{max} - X_{min}}{2}$	> 0.5	< 1
S Shaped	$X_{min} + \frac{X_{max} - X_{min}}{5} < C < X_{min} + \frac{4(X_{max} - X_{min})}{5}$	0.2/0.8	> 1
Decreasing Function			
Linear	$C \approx X_{min}$	≈A0	≈1
Convex	$X_{max} < C < X_{max} + \frac{X_{min} - X_{max}}{2}$	< 0.5	> 1
Concave	$X_{min} - \frac{X_{min} - X_{max}}{2} < C < X_{min}$	> 0.5	< 1
S Shaped	$X_{max} - \frac{4(X_{max} - X_{min})}{5} < C < X_{max} - \frac{X_{max} - X_{min}}{5}$	0.2/0.8	> 1

A sustainability index (SI) is assigned to the GVAK based on the parameters.MIVES is a one of a kind of Multi Critria Decision Analysis strategy. MIVES depends on distinguishing diverse

criteria, which are additionally separated into indicators. MIVES approach utilizes concept of value function to quantify the indicators. Based on the maximum and minimum satisfaction values the indicators values are rated between 0 & 1(Joglekar et al. 2018). Such kind of arrangement helps to evaluate a certain alternative by assigning an index called Sustainabiliy index. MIVES methodology is applied for calculation of Sustainability Index.

Table 4.10 shows the different criteria involved and weightages assigned for calculation of SI.

Table 4.10: Different criteria and weightages assigned for calculation of SI

Criteria	Impact category
VI1) Economic (40%)	Profit (100%)
VI2) Social (30%)	Financial Status (30%)
	satisfaction (20%)
	Training requirement (30%)
	Social Status (20%)
VI3) Environmental (30%)	Energy use (50%)
	Product Replacement Potential (50%)

Value function:

All the indicators having different values hence a value function (VF) is assigned (between 0 and 1) based on the maximum satisfaction (value function 1) and minimum satisfaction (value function 0) values. However the data obtained for environmental and social criteria are already in the range of 0 and 1 hence the data is directly used for further calculations.

Table 4.11 shows the values and value function of individual indicators

Table 4.11Value function calculations

Criteria	Impact category	Smax	Smin	C	K	P	Type of Curve	GVAK	VF
Economic	Profit	933918.5	235930	1000000	0.55	0.5	IC_v	667,084.67	0.823
Social	Financial Status	1	0	The responses are scaled linearly between 0 and 1				0.44	0.440
	Health satisfaction	1	0					0.675	0.675
	Training requirement	1	0					0.805	0.805
	Social Status	1	0					0.775	0.775
Environmental	Energy use	1	0					0.722	0.722
	Product Replacement Potential	1	0					0.4	0.4

CHAPTER 5: RESULT AND DISCUSSION

Finally, based on the aforementioned criteria, value function, and weights given in Table 5 & Table 5.1, SI for each alternative is calculated and tabulated (Table7).

Table 5.1 Calculation of value function of criteria

	VI1	VI2	VI3
GVAK	0.82	0.66	0.56

GVAK scores economic parameter as the products are produced as per market demand. Majority of products are manufactured as per the sales trends observed. Also most of the raw material other than CDU is procured in bulk and used as per requirement.

GVAK has a significant social impact. As already discussed all the manpower are sourced from nearby villages providing employment benefits to all individual. Health check up camps are organized periodically in co ordination with reputed hospitals as a part of hosipital's Corporate Social Responsibility activity. Besides relatively less training is required for individuals that wish to join the organization which enables them to provide regular employment opportunities to people. As a result GVAK helps in upliftment of the social status of the people working which have a very limited employment opportunity.

One major aspect that needs to be addressed is the financial status. GVAK is able to provide minimum wages as approved by Governement of India, yet they are not able to increase their spending on account of relatively less product penetration in the markets.

Table 5.2 shows the sustainability index calculated by weightages assigned as per Table 5.

Table 5.2 Sustainability index of GVAK

CDU biorefinery	Sustainability Index
GVAK	0.70

It can be inferred that the sustainability index of the GVAK for the above set criteria is found to be 0.7. Such high amount of sustainability index is attributed highly to the good profit margins

availed by GVAK along with its high social impact. With increase in the market demand for the CDU based products, would result in further increase the sustainability index.

5.1 SENSITIVITY ANALYSIS

As the model seems to be hooked in to the relative weights of the factors, a sensitivity analysis is performed with reference to weights. Figure 5.1 shows the sensitivity analysis of sustainability index. It is observed from Figure 2 that there is no appreciable change in overall SI of GVAK. The overall ranking of GVAK in terms of sustainability index appears to be constant for varied criteria weightage.

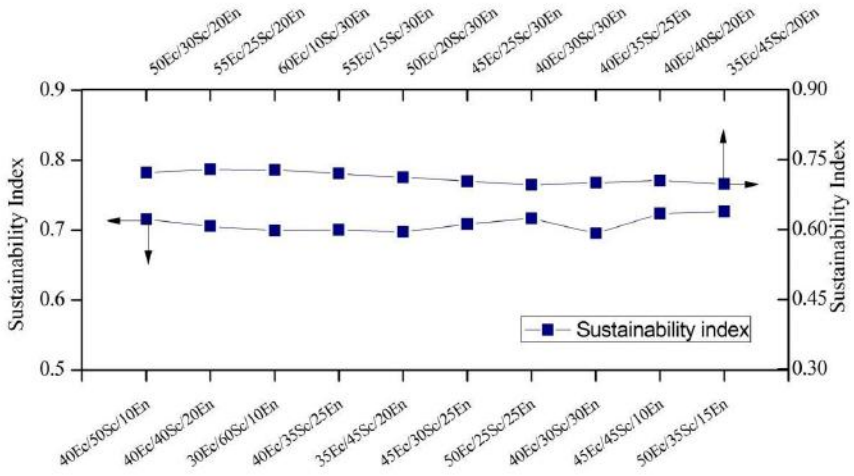

Figure 5.1 Sensitivity analysis of sustainability index for different weightages assigned

5.2 RECOMMENDATIONS

Following recommendations can be implemented to increase the overall sustainability index of GVAK

- The overall market penetration of GVAK products can be increased by aggressive marketing strategies. The increase in the product sales would result into increased avoided impacts along with increase in revenue of the organization. Such an increase in revenue can be utilized in increase the social outreach of GVAK.

- The use of biogas produced in situ for the entire energy requirement would decrease the environmental burden of the manufactured products. Use of advanced cultures for biogas production would increase the overall yield of the fuel.
- Implementation of advanced unit operations and processes would decrease the overall energy requirement of the manufacturing process
- Integration of GVAK with local farmers and cow shelters in the vicinity would help in searching the optimum combination of products.
- Use of optimization tools to optimize the CDU generated for different products based on the market demand, processing setups, skills required and profit earned
- Collaboration with government and non government organization in propogating the products offered by GVAK by scientific validation of products visa vis the available commercially available alternatives.

CHAPTER 6: CONCLUSIONS

Products based on the cow dung and cow urine have been gaining popularity recently. CDU- a waste, is converted to valuable product which can replace the commercially available synthetic products, making it a classical example of biorefinery. Along with the economic feasibility assessment, its sustainability index helps in making a more informed decision for the policy makers & entrepreneurs. It can be seen from Figue 2 that the overall sustainability index of the CDU biorefinery is in the range of 0.68-0.73. With planned interventions, the sustainability index can be further increased.

A more comprehensive study in regards to sustainability assessment of such CDU biorefinery would help in setting up more both research and industrial entities.

CHAPTER 7: REFERENCES

1 Department of Animal Husbandary dairy & Fisheries RashtriyaGokul Mission. In: Gov. India (GOI),. http://dahd.nic.in/about-us/divisions/cattle-and-dairy-development/rgm-rashtriya-gokul-mission. Accessed 3 May 2018

2 Edwin E, Jarald E, et al., 2008 Antioxidant and Antimicrobial Activities of Cow Urine. Glob J Pharmacol 2:20–22. doi: 10.12980/JCLM.2.2014J6

3 Go-VigyanAnusandhan Kendra Go-VigyanAnusandhan Kendra. http://govigyan.com/. Accessed 24 May 2018

4 Hao X, Chang C et al., 2001 Greenhouse Gas Emissions during Cattle Feedlot Manure Composting. J Environ Qual 30:376. doi: 10.2134/jeq2001.302376x

5 International Standardization Organization 2006 ISO 14040 International Standard Environmental management - Life cycle assessment - Principles and framework.

6 Joglekar SN et al, 2018 Sustainability assessment of brick work for low-cost housing: A comparison between waste based bricks and burnt clay bricks. Sustain Cities Soc 37:396–406. doi: 10.1016/j.scs.2017.11.025

7 Johorey J What is a Goshala and How Does it Work. In: Animalwised. https://www.animalwised.com/what-is-a-goshala-and-how-does-it-work-1342.html. Accessed 15 May 2018

8 Korom FJ 2000 Holy cow! The apotheosis of zebu, or why the cow is sacred in Hinduism. Asian Folkl Stud 59:181–203. doi: 10.2307/1178915

9 McLennan JF 2004 The Philosophy of Sustainable Design: The Future of Architecture. Ecotone Publishing

10 Ministry of Agriculture, Department of Animal Husbandary dairying and fisheries 2012 19th Livestock Census-2012: All India Report.

11 Pathak M, Kumar A 2003 Cow praising and importance of Panchyagavya as medicine. Sachitra Ayurveda 5:56–59.

12 Pathak ML, Kumar A 2003 Gomutra -descriptive study. Sachitra Ayurveda 7:81–84.

13 Randhawa GK, Kullar JS 2011 Bioremediation of Pharmaceuticals, Pesticides, and Petrochemicals with Gomeya/Cow Dung. ISRN Pharmacol 2011:1–7. doi: 10.5402/2011/362459

14 Vikaspedia Role of Livestock in Indian Economy. In: Minist. Electron. Inf. Technol. http://vikaspedia.in/agriculture/livestock/role-of-livestock-in-indian-economy. Accessed 24 May 2018

15 Wood S, Cowie A 2004 A Review of Greenhouse Gas Emission Factors for Fertiliser Production.

16 Ola Eriksson, Åsa Hadin, Jay Hennessy, Daniel Jonssonet al., 2016 Life Cycle Assessment of Horse Manure Treatment Energies, 9, 1011; doi:10.3390/en9121011.

17 Augustine Ntiamoah and George Afrane 2007, Environmental impacts of cocoa production and processing in Ghana: life cycle assessment approach, Journal of Cleaner Production 16 (2008) 1735e1740

18 Monika Skowroñska and Tadeusz Filipek, 2014, Life cycle assessment of fertilizers: a review, *Int. Agrophys., 2014, 28, 101-110*

19 Annettek Oehler and Caroline Wildbolz 2009, Comparing the Environmental Footprints of Home-Care and Personal-Hygiene Products: The Relevance of Different Life-Cycle Phases, *Environ. Sci. Technol.* **2009,** *43,* 8643–8651

20 Punam Singh Haripriya Gundimeda & Matthias Stucki, 2014, Environmental footprint of cooking fuels: a life cycle assessment of ten fuel sources used in Indian households, Int J Life Cycle Assess (2014) 19:1036–1048

21 A.J. Komakech C. Zurbrügg G.J. Miito a, J. Wanyama a, B. Vinnerås, 2016, Environmental impact from vermicomposting of organic waste in Kampala, Uganda, Journal of Environmental Management 181 (2016) 395e402

22 BrianKing, 1993, Social impacts of tourism: Host perceptions, AnMLr of Tourism Research, Vol. 20, pp. 650-665, 1993

23 Antonio Aguado , 2011 , A Value Function for Assessing Sustainability: Application to Industrial Buildings *Sustainability* 2011, *3*, 35-50