International Conference on New Era in Technologies, Science and Role of Management
Parvatibai Genba Moze College of Engineering, Wagholi, Pune NETSRM-18
9th-10th April 2018 www.conferenceworld.in ISBN: 978-93-87793-13-2

SUSTAINABLE SANITATION SYSTEM FOR THE CITY

Anand Sheelvanth[1], Arshi S Khan[2], Ashish Hakke[3]

[1]*Civil,Parvatibai Genba Moze College of Engineering Wagholi, Pune, (India)*

[2]*Civil,Parvatibai Genba Moze College of Engineering Wagholi, Pune, (India)*

[3]*Civil,Parvatibai Genba Moze College of Engineering Wagholi, Pune, (India)*

ABSTRACT:

Water is the basic element of social and economic infrastructure and is essential for healthy society and sustainable development. The natural resources like river, lake and ponds are polluted due to the discharge of sewage water into the sources without proper planning. Due to the contamination of the sources by sewage leads to surface water pollution, ground water pollution resulting in serious health hazards, breakup of waterborne diseases and in many instances the rivers getting fully flooded with sewage flow. The priority of the sanitation infrastructure system is always in the last of all the development activity due to the financial and power constraints, hence this live case study is undertaken to design a technically and financially self sustainable ecosanitation infrastructure system for Yadgir city.

Keywords: Healthy society, Sewage water, Pollution, health hazards, Infrastructure, Ecosanitation etc

I. INTRODUCTION

Sustainable sanitation recognizes that in order to be sustainable, a sanitation approach must be socially acceptable and economically viable. In this way, sustainable sanitation is a loop-based approach that differs fundamentally from the current linear concepts of wastewater management, and that does not only recognize technology, but also social, environmental and economic aspects. Sustainable sanitation is an approach that considers sanitation holistically. It recognizes that human excreta and wastewater are not waste product, but a valuable resource. This view is based on the fact that wastewater and excreta contain significant amount of energy, plant nutrients and also water that can be recycled and reused, thus protecting natural resources. Water and Sanitation is one of the primary drivers of public health. This means that once we can secure access to clean water and to adequate sanitation facilities for all people, irrespective of the difference in their living conditions, a huge battle against all kinds of diseases will be won. These words, lent sanitation and health.

This implies the following criteria

- Health and Hygiene
- Environmental and Natural Resources
- Technology and Operation
- Financial and economic issues

The view of general system of sustainable sanitation system is shown in Fig, it is a simplified and idealized technique for use of the treated water and nutrients present in the treated effluent sludge. It improves the yield of crop as well as revenue generation. The system focuses on the treated wastewater, the waste is not a waste it's a important biological resources.

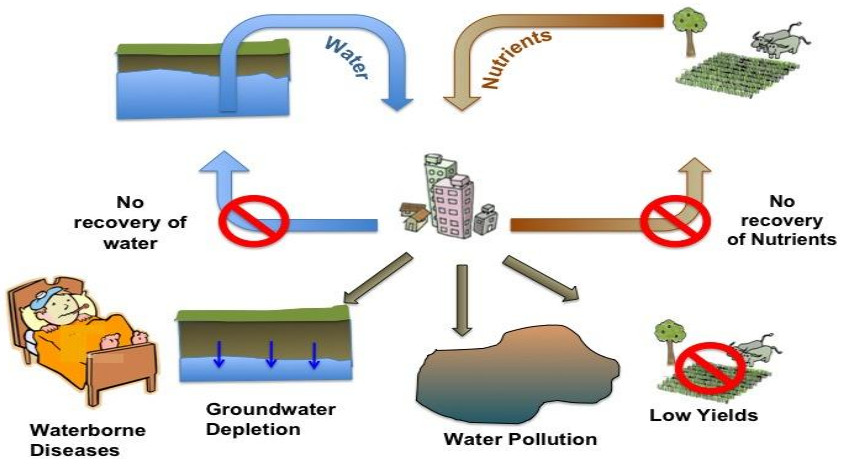

Fig. Sustainable Sanitation System

II. STUDY AREA

Yadgir is a city and the administrative headquarters of Yadgir district in the state of Karnataka. The town covers an area of 5.6 square kilometers (2.2 sq mi). The Bhima River flows through Yadgir town. It has an average elevation of 389m above mean sea level (MSL).The city municipal council jurisdiction extends up to an area of 14.95 sq.km. Population as per 2011 census was 74,294.

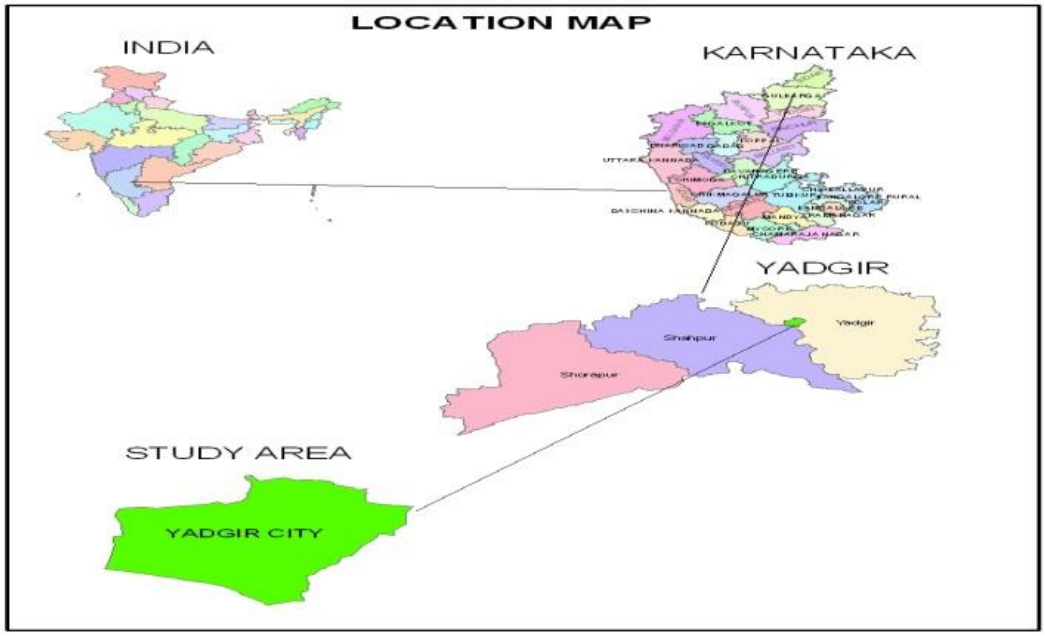

Fig. Location of Yadgir city map

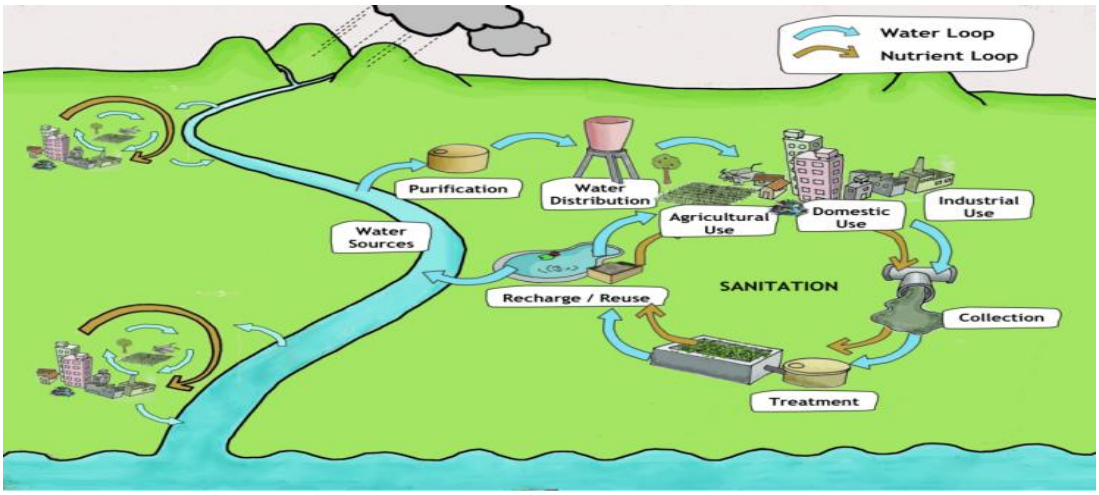

Fig. General system of Sustainable Sanitation System

III CATCHMENT AREA OF DODDANALA

Catchment area is a geo-hydrological unit of all land and water within the confines of drainage divide which contributes runoff to a common point. The Doddanala catchment area is covered by 40,692 hectares (406.92 km^2), which is a basin shaped area of land, bounded by natural features such as hills from which surface and sub surface water flows into streams, river and wetlands. The system of streams which transport water, sediment and other

material from a catchment is called a drainage network. No catchment is exactly like another. Each has a different size, shape, drainage pattern and features that are determined by natural processes, particularly geology and climate as show in Fig

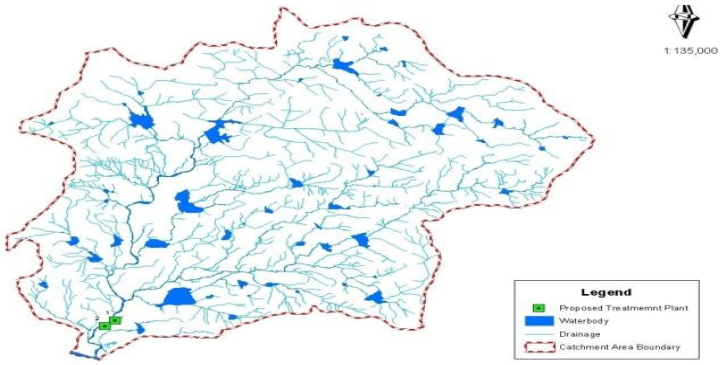

Fig. Catchment area of Doddanala

IV. OBJECTIVES

a. To evaluate the sewage collection system by gravity flow.
b. To evaluate providing treated effluent for agriculture purpose by using GIS and Remote sensing techniques for developing a sustainable sanitary infrastructure
c. To make a detail analysis of cost benefit for self sustainability of the treatment plant maintenance

V. MATERIALS AND METHODOLOGY

In the present study, the maps in fig.no. show the details of the boundaries of the catchment area of Doddanala in the topsheet by using the GIS software (ArcGIS.Ver 10.1) .

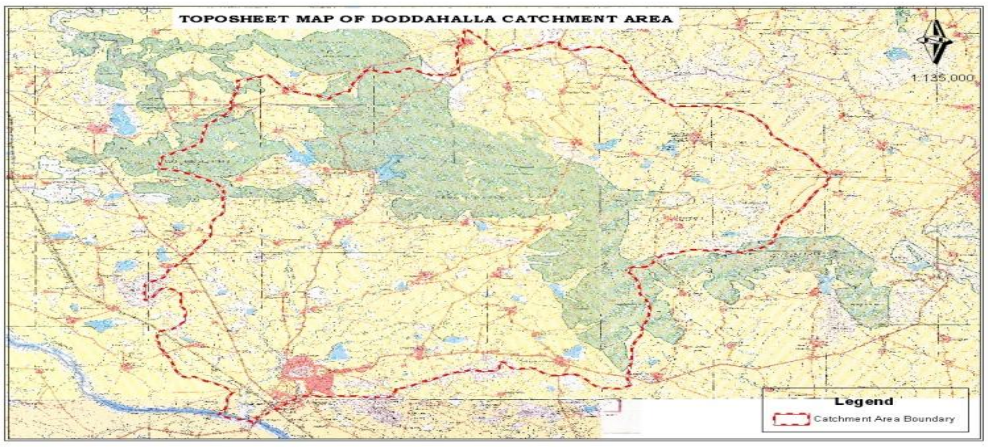

Fig. Toposheet of Doddanala Catchment Area

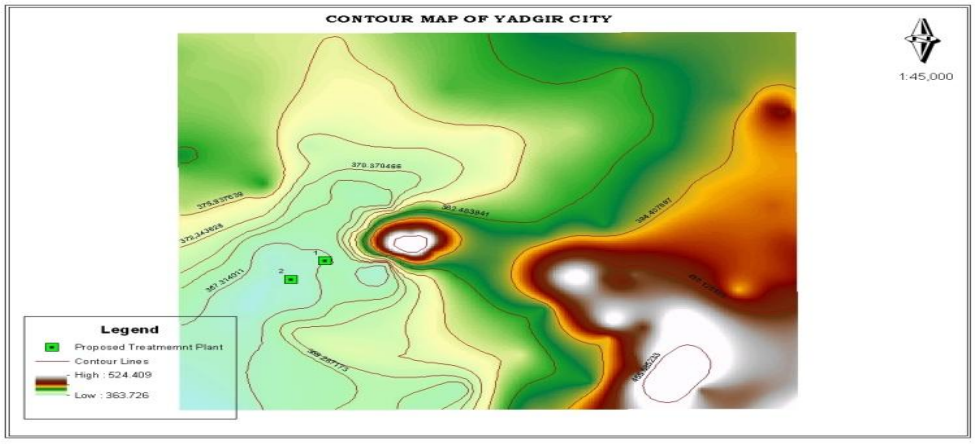

Fig. Contour map of Yadgir city

A. Sampling**:**

The collection of wastewater samples may seem a relatively simple task. The collection of a representative sample becomes much more complex. In the case study, collection of samples carried out once in a week.

B. Sewage Treatment Plant

Stabilization ponds are suggested for the treatment of sewage as it is more suitable in tropical climate with high efficiency in removal of BOD, Total solids and nemotods. It has been internationally recognized that the effluent of the stabilization ponds are more suitable for agriculture as it removes all the nemotods, hookworm, trischinia effectively as compete any other treatment methods. It is also very economical and does not consume any energy in the process. Conventional single treatment unit is avoided and provided with two smaller treatment plants unit to unable the collection of city sewage by the gravity flow.

VI. RESULT AND DISCUSSIONS

Population of Yadgir city as per census department

S. No.	Zones and Ward number	Population (2011)
01	Zone I population(ward no 01-24)	53,566
02	ZoneII population(ward no 25-31)	20,728
	Population as per Census department	74,294

Population Forecasting Methods

A. Arithmetic increase method:

This method is based upon the assumption that, the population increase at a constant rate, i.e. the rate of change of population with time (ie. dp/dt) is constant. $P_n = [P_o + nX]$

Table. Population projection of Arithmetic method

Sl no	Population Projection of Arithmetic Method	
	Year	Population Forecasted
01	2011	74,294
02	2017	82,164
03	2047	1,15,889

B. Geometric increase method

In this method, the per decade percentage increase or percentage growth rate (r) is assumed to be constant, and the increase is compounded over the existing population every decade. $P_n = P_o[1+(r/100)]^n$,

Geometric average $= \sqrt{r1 * r2 * r3..rt}$

Table. Population projection of Geometric increase method

Sl no	Population Projection of Geometric Increase Method	
	Year	Population Forecasted
01	2011	74,294
02	2017	85,874
03	2047	1,59,768

C. Incremental Increase Method

In this method, the per decade growth rate is not assumed to be constant as in the arithmetic or geometric progression methods, but in progressively increasing or decreasing, depending upon whether the average of the incremental increases (increment over the increase) in the past data is positive or negative.

$P_n = P_o + nx + [\frac{n(n+1)}{2}]\ y$

Table. Population projection of incremental increase method

Sl no	Population Projection Incremental increase Method	
	Year	Population Forecasted
01	2011	74,294
02	2017	81,057
03	2047	1,11,039

Geometric increase method is adopted because Yadgir is under developing city, recently it became the district due to this many people migrate from nearby villages. Also population is bound to increase for coming days.

Table. Projected Population and Sewage Generation in Sewerage Zones

Zones of city	Projected Population	Quantity of Sewage Generation (MLD)	Quantity of Sewage Generation (MLD)	Treatment plant location
	2047	2047	SAY	RL in m
Zone I	1,29,473	13.98	14	366
Zone II	63,573	6.86	7	367

D. Doddanala tributary discharge and contamination

The volume of the discharge will be determined by factors such as rainfall, climate, vegetation, soil type, drainage basin relief and the activities of man. In this case study it is observed that the tributary is contaminated with 83% of sewage water as shown in fig no, during 8 months of flow as shown in table no.

It is therefore seen that the major part of the flow in Doddanala tributary constitute of sewage flow contaminating the river Bhima.This kind of scenario is seen all over the world with rapid urbanization and large migration of rural population to the city.

Hence it is envitable to develop a financially and technically self sustainable sanitary infrastructure to protect the precious water.

The calculated Doddanala's peak discharge is 913.686 m^3/sec and cross section required for peak discharge is 155.124 m^2, and the width of Nala required for peak discharge is 32.52 m.

Present scenario of Doddanala tributary from October to May

Month	Runoff water discharge in m^3/sec	Sewage water discharge in mld
Jan	84.59	651
Feb	66.88	588
Mar	37.21	651
Apr	16.48	630
May	13.19	651
Oct	390.91	651
Nov	306.13	630
Dec	117.74	651
	1033.12	**5103**

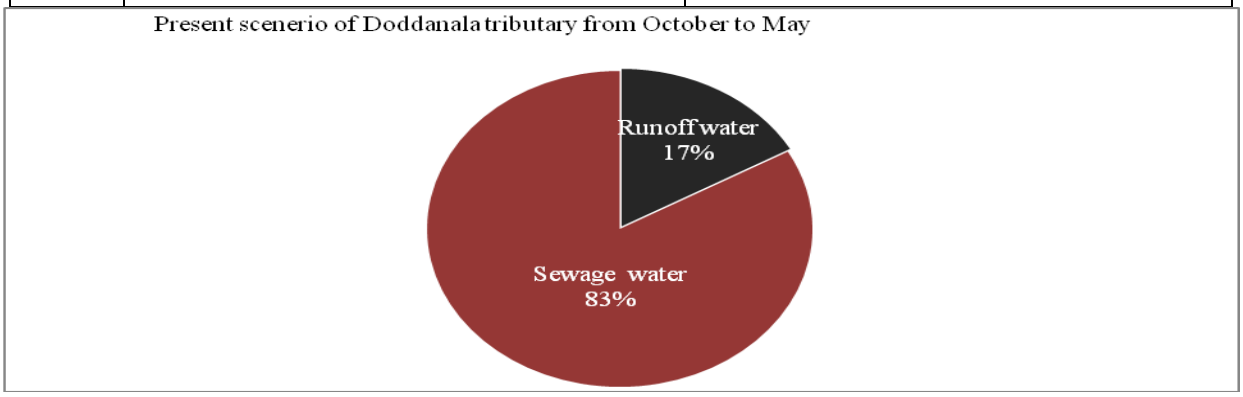

Fig: Doddanala view in Google earth

E. Impounding reservoir for conserving of treated Wastewater:

It is designed for 365 days detention time taking into consideration excess water flow during rainy season the RL of reservoir is kept in the 386 m, and distance from treatment plants is 2KM, as per the analysis and study of the topomaps, revenue maps, and RS data with analysis made using GIS, the average RL of the agriculture field is 378 m hence gravity flow of the effluent to the field to ensure that the treated water is providing to irrigation purposes.

Diameter of the proposed impounding reservoir to conserve treated effluent is 493.95 m and the effective depth is 3.33 m with free board of 0.3 m extra

H. Requirement of treated effluent for irrigation purposes

The following crops are sown in the Yadgir such as bajra, toor, sugarcane, groundnut, sunflower, sesame, castor bean, black gram, jowar, wheat, cotton, ragi, bengal gram, and linsed are some of the major crops grown.

In this case study, the groundnut and cotton which are cash crops can be grown in the available soil conditions giving high returns.

The requirement of water and net area that can be irrigated by the available treated effluent from the treatment plants is shown in the following table no.

Table: Requirement of treated water for irrigation purposes

Crops	Requirement of water in (mm)	Crops period (days)	Net area of land irrigated	Required water for 1 acre of land in MLD
Groundnut	500-550	105 2 crops / year	4009091 m2 (990 acres)	0.23
Cotton	550-600	165	5775000 m2 (1426 acres)	0.4

The groundnut can be grown in 990 acres of irrigated land or cotton can be grown in 1426 acres of land.

The crop rotation can be made by this two above mentioned crops.

I. Revenue Generation from Wastewater Treatment Plants:

30 years plan period is considered and the amount of input sewage to the sewage treatment plant and consequently, the amount of productive wastewater is increasing, the incomes of the plan are determined and the general results are outlined in cost-benefit analysis (CBA). We have expressed and brought this time factor with the calculation of a period and income return in analysis. This is the very time that should be spent for the return of obtained incomes of a change in its costs.

i) Selling of treated effluent:

Treated effluent which improves the crops yield and as well as revenue generation, the treated effluent is 21mld

Generation of treated effluent	Acre of land irrigated	Unit rate (0.058 rupees each m^3) In rupees
21,000m^3 / day	7 acres	1,218
6,30,000m^3 / month	210 acres	36,540
76,65,000m^3 / year	2000 acres	3,48,000
3832 m^3 / day	1 acre	174

ii) Selling of effluent sludge:

The treated effluent sludge which has rich nutrients, improves the soil nutrients as well as crops yield,

Generation of effluent sludge	Unit rate (0.015rupees each m^3) In rupees
21,000m^3 / day	315
6,30,000m^3 / month	9,450
76,65,000m^3 / year	1,14,975

Pumping Cost:

Power required per	Working hour in hours	Energy required in KWh	Cost of electrical energy@4rupees per unit in rupees
91.18 KW/day	8	729.45	2,918
2754 KW/month	240	21,883.2	87,533
33280.7 KW/year	2,920	2,66,245.6	10,64,982

J. Operation and maintenance of the sanitary infrastructure:

Total source income

Source	Unit rate	Income in rupees
Selling of treated effluent	1218 x 365days	3,48,000
Selling of effluent sludge	315 x 365 days	1,14,975
Subscription fee	1000 x 2000 acre	20,00,000
Total income		24,62,975

Total cost

Contents	Unit rate	Cost
Pumping cost	2918 x 365days	10,65,070
Labours charge (5No's)	15000 x 5 x 12months	9,00,000
Total cost		19,65,070

Over all Income = Total Income in rupees - Total Cost in rupees

=24,62,975 – 19,65,070

∴ Over all Income = 4,97,905 rupees/year

VII CONCLUSION

- In our case study it was noted that Yadgir city does not have any treatment unit and discharges the sewage water directly into the Doddanala which ultimately joins river Bhima, So the river gets polluted, the same water is distributed to the Yadgir city for drinking purpose.
- The population study was made as per the census and population projection for the design period of thirty years was 1,93,046, the total sewage discharge is 21 mld.
- The integrated application of Remote sensing data, toposheets, revenue maps, wardwise maps and GIS software clearly indicates the necessity of two treatment plants of capacity 14 mld in zone-I of RL 366m, and 7 mld in zone-II of RL 367m, so that the sewerage system of the whole city can be designed under gravity flow with a zero energy consumption. The Yadgir city was divided into two zones to enable gravity flow with each zone having separate treatment plant.

- The treated effluent contains high amount of nutrients such as phosphorous, nitrogen and other rich nutrients, and hence the treated effluent has a high commercial value if used for agriculture purpose
- The treated effluent could be stored in a artificial lagoon/impounding reservoir which is on RL 386m, and further used for the agricultural purposes, 2524 acres of land to be irrigated of the annual volume of treated wastewater is 76,65,000 m^3.
- For the self sustainability of treatment plant which generates treated wastewater and productive fertilizer evaluates the cost's income as the annual selling of treated wastewater generates the 4,44,570 rupees, and selling of productive fertilizer generates the annual cost is 1,14,975 rupees and annual pumping cost is 10,65,070 rupees, 5No's of labours and their annual base payment is of 9,00,000 rupees (Each 15,000rupees/month) and subscription fee for each acre of land to be irrigated is 1000 rupees/year. Hence the overall income of the project is 11,18,475 rupees. This case study leads to the sustainable development in sanitation system of the city.

REFERENCES

[1] Susanaa .Thematic paper (October 2008).Sustainable Sanitation alliance. Version 1.2

[2] Eeva Sundstrom (June 2010). Application and use of GIS in Small Sanitation Projects in Developing Countries. Tampere University of Applied sciences Department of Environmental Engineering:

[3] Aime Tsinda, Pamela Abbott, Steve Pedley, Katrina Charles, Jane Adogo , Kenan Okurut and Jonathan Chenoweth:Challenges to Achieving Sustainable Sanitation in Informal Settlements of Kigali, Rwanda. Int.J.Environ.Res.Public Health 2013,10,6939- 6954;doi:10.3390/ijerph10126939

[4] Jennie Barron, Patric Buker, Guoyi Han, Charles Young. Managing environmental systems: supporting sustainable urbanization. Published by Stockholm Environment Institute (2014)

[5] Linda S. Gaulke, Xiao Weiyang, Andrew Scanlon, Amanda Henck, Tom Hinckley: Evaluation Criteria for Implementation of a Sustainable Sanitation and Wastewater Treatment System at Jiuzhaigou National Park, Sichuan Province, China. Published (19 November 2009); DOI 10.1007/s00267-009-9398-1

[6] Emelie Walsund, Joseph Strahl (2013); Geographical Information Systems as a Tool in Sustainable Urban Development. Sustainable Urban Management Malmö University:

[7] Christoph Luthi, Jennifer McConville, Anna Norstrom, Arne Panesar, Rahul Ingle, Darren Saywell, Thorsten Schutze: Rethinking Sustainable Sanitation for the Urban Environment. 4th International Conference of the International Forum on Urbanism (IFoU, 2009).

[8] Gikas G.D, Tsihrintzis V.A;Stabilization Pond Systems for Wastewater Treatment: Facility costs and Environmental Footprint Assessment.Global Nest Journal, Vol 16, No 2, pp 374- 384,2014

[9]Phuntsho, H.K. Shon, S. Vigneswaran and J. Kandasamy; Wastewater Stabilization Ponds (WSP) for Wastewater Treatment. Vol II; Faculty of Engineering, University of Technology, Sydney, Australia:

[10] Prof. Dr. Mohammed Ali I. Al-Hashimi Eng. Hayder Talee Hussain; Stabilization Pond for Wasteater Treatment. European Scientific Journal May 2013 edition vol.9, No.14 ISSN: 1857 – 7881 (Print) e - ISSN 1857- 7431.

[11] Kudamnya, E. A. Schoeneich, K. Garba, M. L. Remaining Storage of the Zaria Impounded Reservoir and Rate of Erosion in Its Drainage Basin. American International Journal of Contemporary Research Vol. 3 No. 8; August 2013; Department of Geology Ahmadu Bello University Zaria.

[12] Ameen Rageh: Impacts Assessment of Treated Wastewater Use in Agriculture Irrigation in Amran Area, Republic of Yemen. Agricultural Research and Extension Authority, Dhamar, Yemen

[13] Sources from Wikipedia of Sustainable sanitation system, irrigation system, impounding reservoir, sewage treatment plant, organic farming datas are sourced.