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# Socio-Economic Development of Women Farmers Through Biogas Slurry-Based Manure Management: With Reference to Farmers of Sundarban, West Bengal

Sima Das[1], Dr. C.L. Gour[2]
[1,2] *Department of Extension Education, Mansarovar Global University, Sehore, M.P., India.*

***ABSTRACT:***
*This study examines the socio-economic development of women farmers in the Sundarban region of West Bengal through biogas slurry-based manure management. Women play a significant role in livestock rearing, agricultural activities, household energy management, and the utilization of organic resources in rural communities. However, their contribution to farm-based resource management often remains undervalued and underutilised as a means of livelihood enhancement. Biogas slurry, a nutrient-rich by-product of biogas production, offers an environmentally sustainable alternative to conventional chemical fertilisers while creating opportunities to improve farm productivity, generate income, and enhance women's participation in agricultural decision-making.*

***KEYWORDS:*** *Sundarban, Biogas slurry, Renewable Resources*

## I. INTRODUCTION:

Sundarbans is a vast mangrove forest and delta region in southern West Bengal. It is famous for its unique ecosystem, waterways, and the Royal Bengal Tiger. Socio-economic development of women farmers refers to improving the economic condition, social status, decision-making power, access to resources, and overall quality of life of women engaged in agriculture.

**Biogas slurry-based manure management** is the practice of using the nutrient-rich residue left after anaerobic digestion of animal dung and other organic wastes as a fertiliser or soil amendment. Instead of treating the slurry as waste, it is collected, stored safely, processed, and applied to agricultural land.

Biogas slurry is the material remaining after organic matter such as **cattle dung, poultry manure, kitchen waste, or agricultural residues** undergoes anaerobic digestion in a biogas plant.

It generally contains:

- Nitrogen (N)
- Phosphorus (P)
- Potassium (K)
- Organic matter
- Micronutrients
- Moisture

**Advantages**

- **Recycles organic waste** into a useful agricultural input.
- **Improves soil organic matter** and can contribute to better soil structure.
- **Supplies plant nutrients**, reducing dependence on some chemical fertilisers.
- Proper management can reduce uncontrolled discharge of organic wastes into water bodies.
- Can reduce manure-disposal costs and provide an additional farm input.
- Creates a **circular system**: animal waste → biogas → energy + slurry → fertilizer → crop production.

**BIOGAS AS A RENEWABLE ENERGY SOURCE**

Energy sources can be either renewable or non-renewable. Renewable energy sources include solar power, wind power, hydropower, marine power, geothermal power, biomass, and any other energy source that can be replenished naturally. Renewable resources are infinite because they can renew themselves through processes such as photosynthesis, bioremediation, and cellular respiration. Renewing renewable resources takes only a few human generations. You can't say "a few generations" when discussing resources that can be replaced over extremely lengthy geological periods. To illustrate the point, rocks are naturally recycled, but the rate of

recycling is thousands of times lower than the rates of human usage, rendering rocks practically non-renewable. So, resources that cannot be recycled or that regenerate at extremely slow rates are considered non-renewable. Solar energy is considered renewable despite the sun's finite lifespan for two reasons: first, it is produced at a rate greater than our ability to use it, and second, many human generations will pass before the sun eventually stops providing energy.

Renewable energy sources in India have enormous potential and several methods have been developed to tap into it. If we look at the number of installations or overall capacity, we may get a sense of the present and future of the most significant renewable energy devices and sources utilized in India. Even if just a small portion of this capacity is used, it is still possible to provide the whole energy demand of the country.

Capitalising on these vast opportunities, India has started a massive renewable energy initiative that integrates all of these technologies. The prime minister of India has set a lofty goal for the country's new power generation capacity: 10% renewable energy. It is obvious that pollution from traditional energy sources harms both humans and the planet. In addition, the high cost and limited supply of fossil fuels make their reliance on them for electricity generation unsustainable. That is why it is critical to investigate energy-saving technologies and renewable fuel options without delay.

Renewable energy sources have several benefits, such as (i) being sustainable over time and (ii) utilizing locally accessible resources that can be easily transported without extensive planning, (iii) being suitable for decentralized applications and usage in remote areas; (iv) having a low gestation period and being less capital intensive; (v) being modular in nature, meaning that small-scale units and systems can be nearly as economical as large-scale ones; (vi) being environmentally friendly; and (vii) being able to be used effectively for both increasing the availability of power and promoting social justice and rural development. Consequently, there is a growing global consensus in favour of renewable energy sources as clean, sustainable power sources.

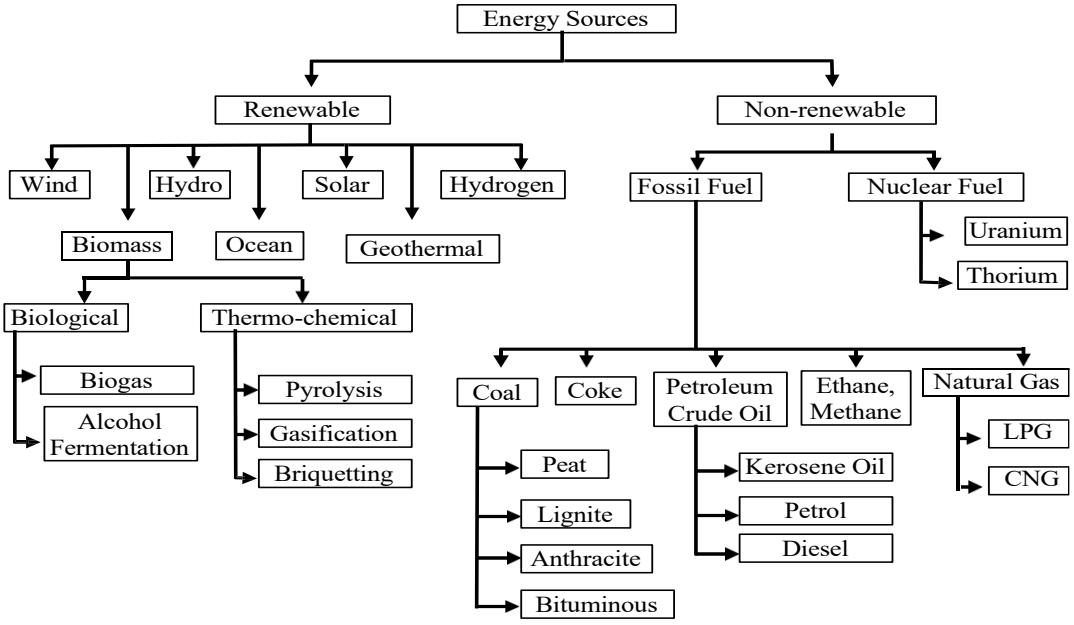



**Fig.1. Classification of Energy sources into Renewable and Non-renewable**

*Source:https://www.researchgate.net/publication/261136066_Biogas_Technology_towards_sustainable_development*

Biogas is a renewable energy source. Like all other renewable energy sources, the energy for biogas generation comes from the sun, through photosynthesis by plants (Fig. 2.). The plant biomass, the storehouse of solar energy is used either directly as feedstock to run the biogas plant or after partial digestion in animal guts. Ruminants consume plant biomass in both dry and green forms. The dry fodder consumed are usually in the form of crop straw, residuals of cereals, pulses, oilseeds after harvesting of the crop produced while in mountain regions grasses from permanent pastures and forest areas are fed.

Biogas is obtained from these animal wastes through anaerobic digestion in digesters. Inside the biogas plant the complex organic polymers, primarily carbohydrate, lipids and proteins in the biomass are fermented to produce biogas mainly comprising of methane and carbon dioxide. In the last few decades biogas has assumed considerable importance as an alternative to conventional energy sources throughout the world, particularly in developing countries like China and India.

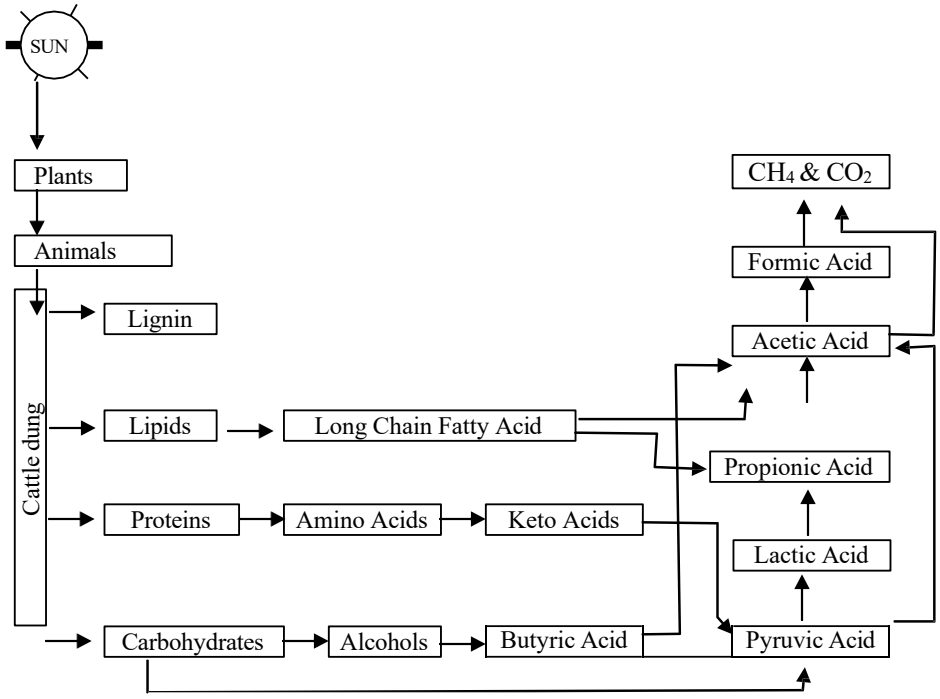



**Fig 2 : Biogas as a Renewable Energy**

*Source:https://www.researchgate.net/publication/261136066 Biogas Technology towards sustainable develo pment*

**OBJECTIVES OF THE STUDY:**

1. To analyse regarding employment opportunities for rural unemployed women of Sundarban by selling surplus biogas slurry.
2. To find out alternative way for reducing drudgery for women members of household in Sundarban area for improving socio-economic status.

## II. RESEARCH METHODOLOGY :

Every research has some purpose and motives. Just as the present research also has a purpose and motive, the word 'Research' is the combination of two words:

(i) 'Re' means again and again, and

(ii) 'Search' means to find out.

In other words, the meaning of the word 'research' is to search for something new or to observe a phenomenon in a new context that is already known. The Advanced Learner's Dictionary of Current English explains research as "a careful investigation or inquiry specially to search for new facts in any branch of knowledge". It is clearly stated that research is the process by which a researcher repeatedly observes a phenomenon and collects data. The data may be numerical, non-numerical, or both. The researcher draws conclusions based on the collected data.

In the present study, a descriptive research method was used, and data were collected through a questionnaire survey.

**Primary Data**

With the main objectives of the study in view, primary data were collected directly from the selected women respondents through a questionnaire in the Basanti block of South 24 Parganas district, West Bengal. The questionnaire includes different aspects of the respondents, such as socio-demographic characteristics of the households, agricultural farming system, farmers' perceptions and attitudes towards use of fertilizers/slurry, factors influencing farmers' fertiliser purchasing decisions, current manure management practices, benefits and drawbacks, willingness to adopt new technologies, and open-ended comments.

**SAMPLING METHOD:**
In non-probability sampling, the judgement sampling method has been implemented.

**SELECTION OF AREA:**
Basanti block of South 24 Parganas district has been selected for the present study because women marginal farmers are using biogas in this area, and it is convenient for me to collect data through a questionnaire. Hence, in view of the above facts and the limitations of time and resources, this district has been selected.
The total sample size of the study is 170 women in the Basanti block of South 24 Parganas district, West Bengal. The biogas slurry management implementation was started but did not reach all the women in the block. So, the actual biogas slurry manure is managed by only 170 women.
In the present study, the essential supporting primary source information was collected through the Interview Schedule.

**I. SOCIO-DEMOGRAPHIC CHARACTERISTICS OF THE HOUSEHOLD**
**1. AGE:**
The age was tabulated from raw data collected from the survey report which are as follows:

**Table 1: Age percentage of the respondents**

| Age | Frequency | Percentage |
|---|---|---|
| 30-35 | 65 | 38% |
| 35-40 | 48 | 28% |
| 40-45 | 41 | 24% |
| 45-50 | 15 | 9% |
| 50-55 | 1 | 1% |
| Total | 170 | 100% |

*Source: Primary Data*

The data shown was majority of the women belongs to age group 30-35 years and their percentage is 38%. The age group of 35-40 years has 28 %, 40-45 years of age group is 24%, 45-50 years of age group is 9% and age group 50-55 years is 1%.

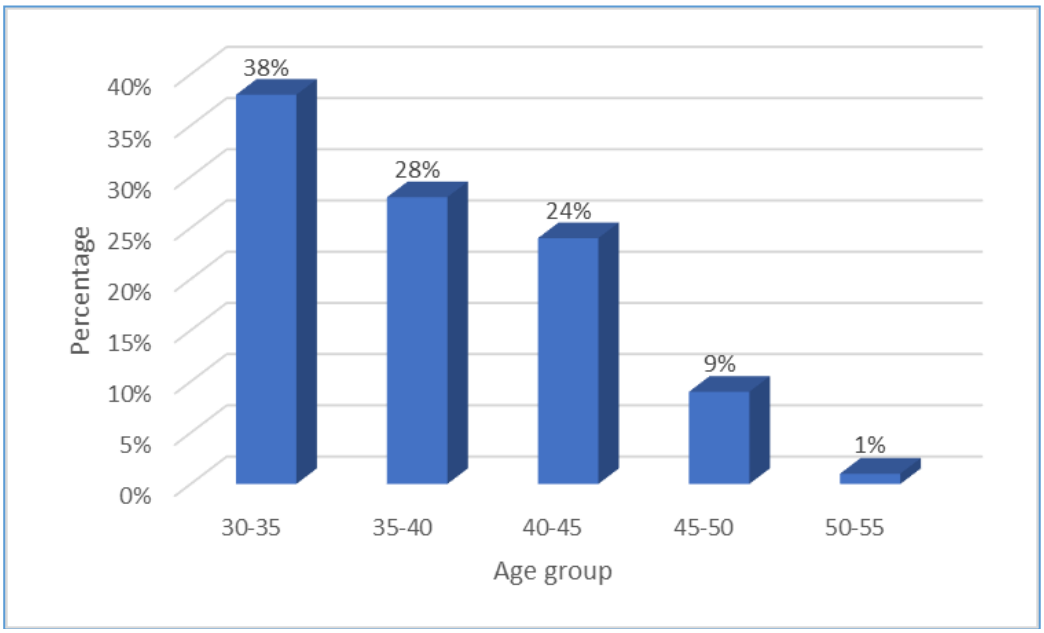



**Fig 3: Bar graph showing age percentage of the respondents**

**2. FEMALE HEADED HOUSEHOLD**
The data was collected regarding head of the household from respondents and it was found that none of the household is headed by female. The data was collected by scale No=0 and Yes=1.

**Table 2: Female headed household percentage of the respondents**

| Option | Frequency | Percentage |
|---|---|---|
| Yes | 0 | 0% |
| No | 170 | 100% |
| Total | 170 | 100% |

*Source: Primary Data*

The data shown that the female headed household percentage was 0% and male headed household was 100 %.

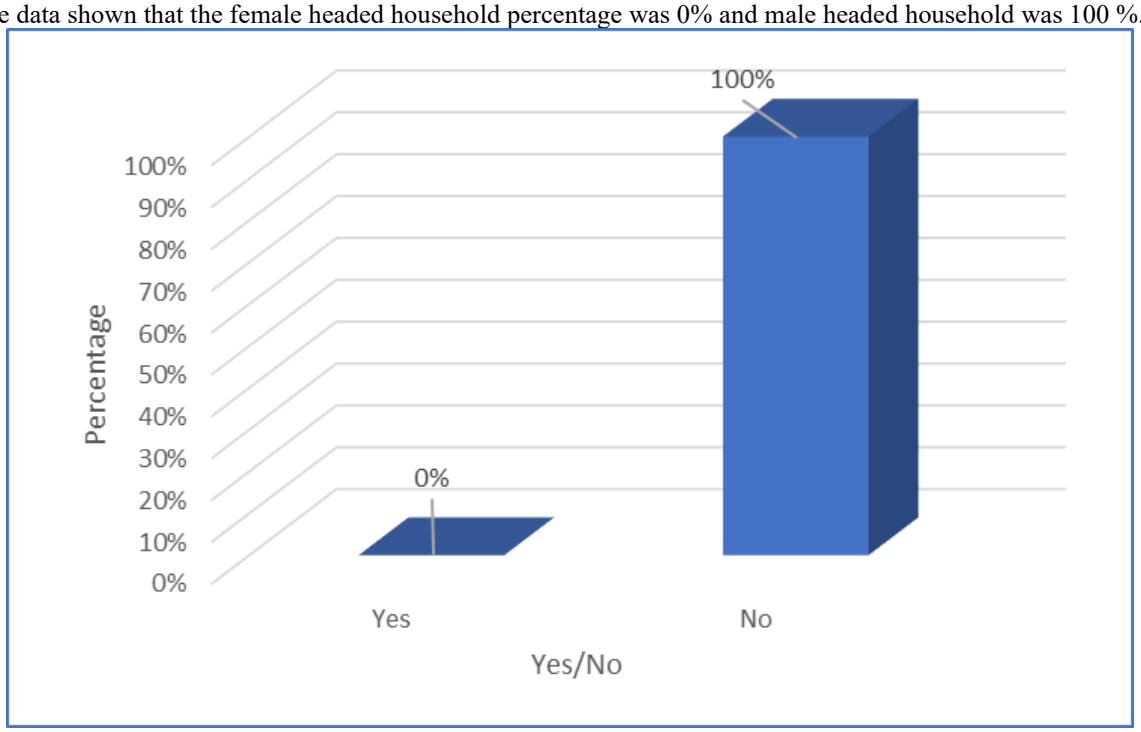



**Fig 4: Bar graph showing female headed household percentage of the respondents**

## III. MARITAL STATUS

The marital status data was collected in scale (1=married, 2=single, 3=divorced, 4=widowed) and it was observed that 100% of the respondents was married.

**Table 3: Marital status percentage of the respondents**

| Marital Status | Frequency | Percentage |
|---|---|---|
| Married | 170 | 100% |
| Single | 0 | 0% |
| Divorced | 0 | 0% |
| Widowed | 0 | 0% |
| Total | 170 | 100% |

*Source: Primary Data*

The data collected shows that 100 % of the respondents was married.

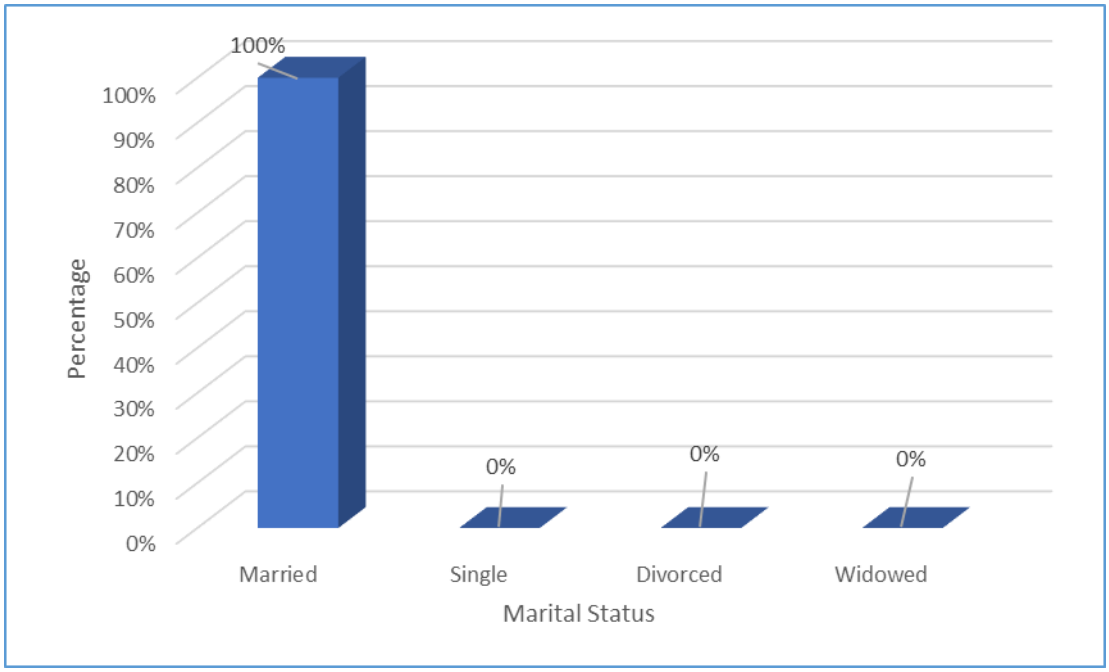



**Fig 5: Bar graph showing marital status percentage of the respondents**

### 3. EDUCATIONAL LEVEL

The data was collected from the respondents regarding the educational status of them in scale (1= none, 2= Read and write, 3= Elementary, 4= high school, 5= vocational training, 6 = intermediate diploma, and 7 = Bachelor and above), and it was found that 100 per cent of them had an elementary education level.

**Table 4: Educational level percentage of the respondents**

| Educational level | Frequency | Percentage |
|---|---|---|
| None | 0 | 0% |
| Read and write | 0 | 0% |
| Elementary | 170 | 100% |
| High School | 0 | 0% |
| Vocational training | 0 | 0% |
| Intermediate Diploma | 0 | 0% |
| Bachelor and above | 0 | 0% |
| Total | 170 | 100% |

*Source: Primary Data*

The data shows 100 % of the respondents had an elementary educational level.

### 4. FAMILY SIZE

The data was collected from the respondents regarding family size. The data was taken told by the women farmers regarding their family size.

**Table 5: Family size percentage of the respondents**

| Family Size | Frequency | Percentage |
|---|---|---|
| 4 | 54 | 32 |
| 5 | 83 | 49 |
| 6 | 33 | 19 |
| Total | 170 | 100% |

*Source: Primary Data*

The data show that 32 % of the women revealed that their family members are 4, 49 % of the women respondents said that their family members are 5 and 19% said that their family members are 6.

## II. AGRICULTURE FARMING SYSTEM

### 5. SOURCE OF INCOME

The data were collected for the main source of income, and it was found that the main source of their income was agriculture for all 170 respondents. The scale was taken as 1=Agriculture (specify crops), 2= Livestock (specify types of animals), 3= Employment (specify the type of job), and 4= Other.

**Table 6: Percentage of source of income of respondents**

| Source of Income | Frequency | Percentage |
|---|---|---|
| Agriculture (Crop-Paddy) | 170 | 100% |
| Livestock | 0 | 0% |
| Employment | 0 | 0% |
| Other | 0 | 0% |
| Total | 170 | 100% |

*Source: Primary Data*

The data shows that 100% of the respondents were farmers and their main source of income is agriculture.

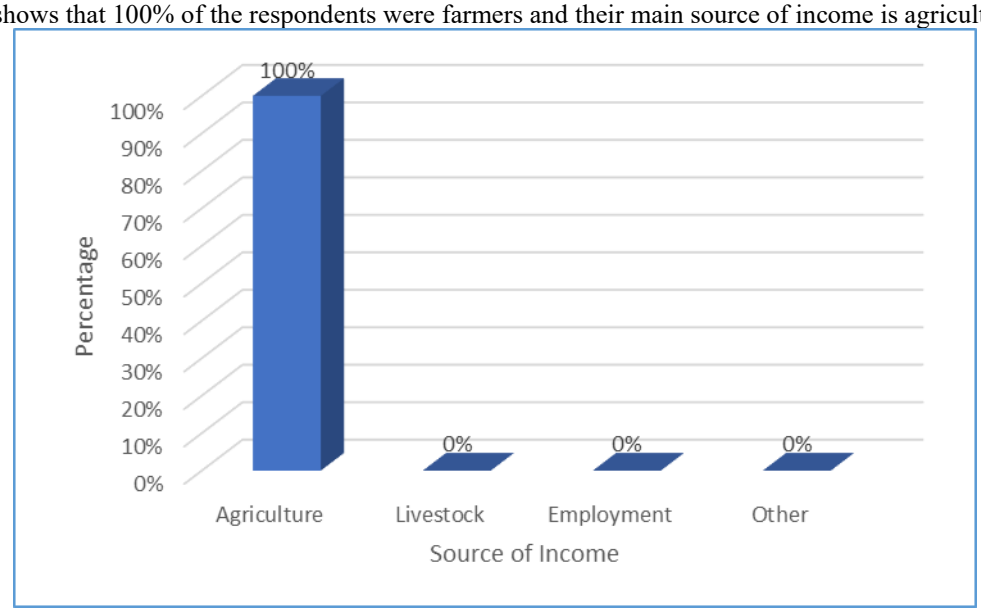



**Fig 6 Bar graph showing percentage of source of income of respondents**

### 6. EMPLOYMENT STATUS

The data was collected from respondents regarding their employment status on a scale 1= Full-time employment, 2= Part-time employment, 3= Unemployed, 4= Retired, 5= House work, and 6= Farm work

**Table 7: Percentage of employment status of respondents**

| Employment status | Frequency | Percentage |
|---|---|---|
| Full time | 0 | 0% |
| Part time | 0 | 0% |
| Unemployed | 0 | 0% |
| Retired | 0 | 0% |
| House work | 0 | 0% |
| Farm work | 170 | 100% |
| Total | 170 | 100% |

*Source: Primary Data*

The data revealed that 100 % of the respondents are employed in farm work. And the other areas are not noticed.

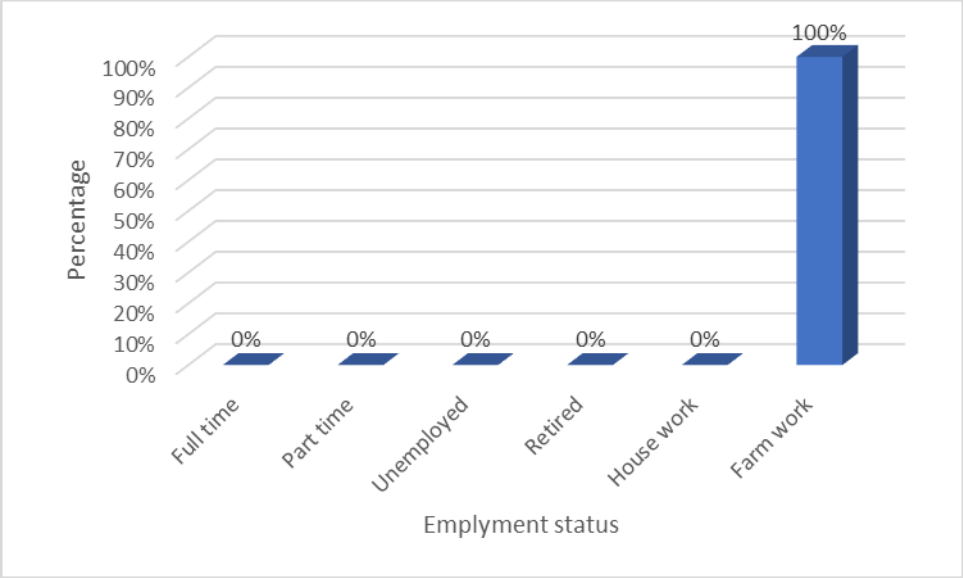



**Fig 7: Bar graph showing percentage of employment status of respondents**

## 7. SIZE OF AGRICULTURAL LAND AND TYPE OF CROPS GROWN

The same data was observed regarding the agricultural land. The data shows 82 % have 0.8 acre of land and 18 % of the respondents have 1 acre of land. The majority of the farmers have 0.8 acre of land.

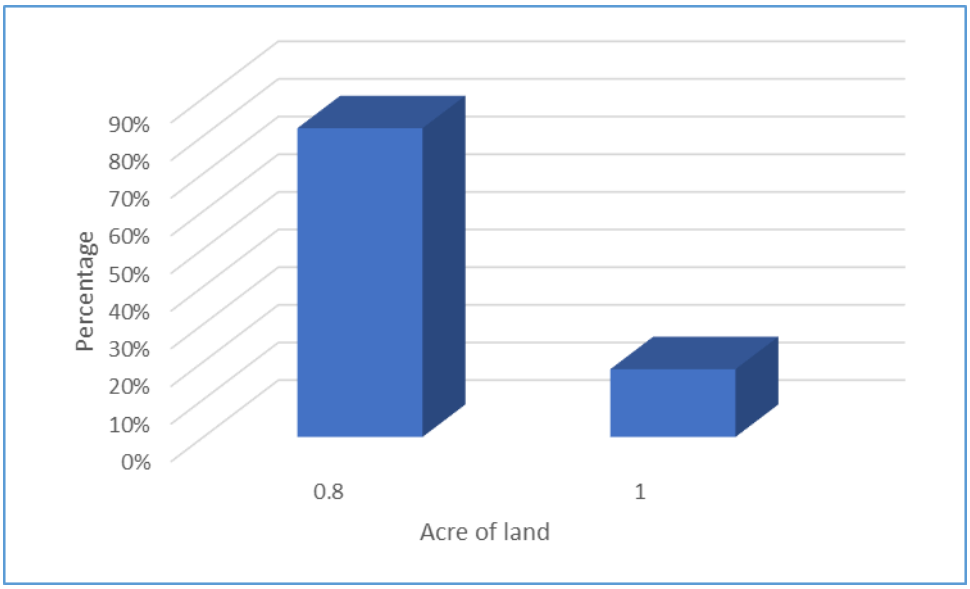



**Fig 8: Bar graph showing percentage of the size of the cultivated land**

**Table 8:** The cultivation of land is done in three seasons, and the main crops grown is as follows :-

| Kharif(Seasonal Vegetable) | Rabi((Seasonal Vegetable) | Zaid(Seasonal Vegetable) |
|---|---|---|
| Paddy | Potato and Khasari Daal | Moong Dal |

All the respondents said that they grow all the above crops is various seasons.
The data was collected in scale 1=Yes, 0=No for organic fertilizer. And 100 % answered that 'Yes'.

**Table 9: Percentage of organic fertilizer among respondents**

| Acre | Frequency | Percentage |
|---|---|---|
| Yes | 170 | 100% |
| No | 0 | 0% |
| Total | 170 | 100% |

*Source : Primary Data*

The data shows that 100 % of the respondents use organic fertilizers.

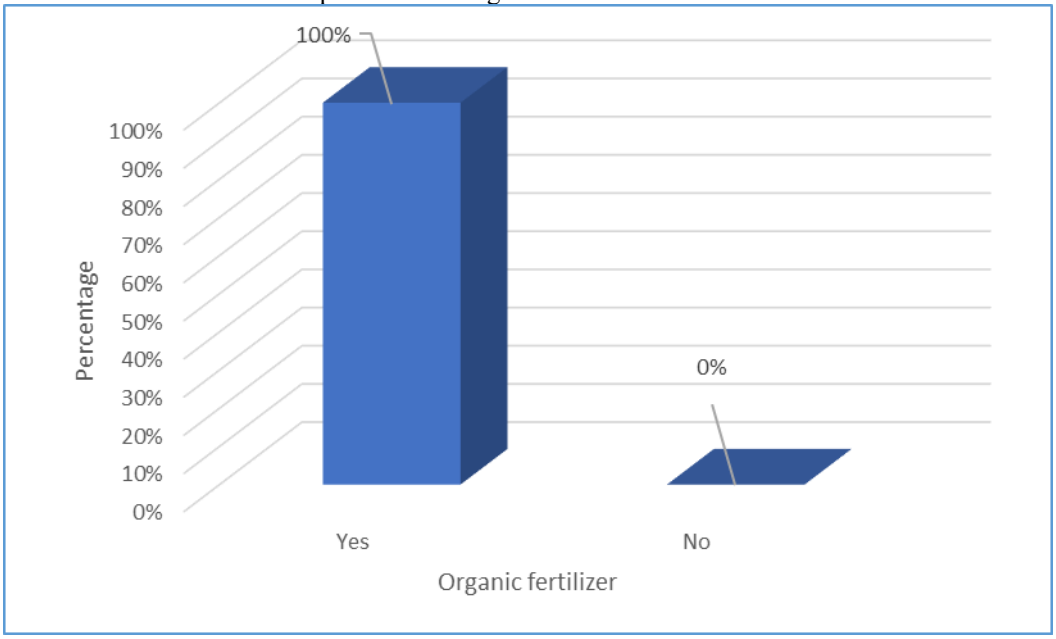



**Fig 9: Bar graph showing percentage of organic fertilizer among respondents**

## 8. SOURCE OF ORGANIC FERTILIZER

The data were collected on the source of organic fertiliser, with responses on a scale of 1=Own farm, 2=Bought, 3=Both 1 & 2. The data were tabulated as follows :-

**Table 10 : Percentage of source of organic fertilizer**

| Response | Frequency | Percentage |
|---|---|---|
| Own farm | 0 | 0% |
| Bought | 0 | 0% |
| Both own farm & bought | 170 | 100% |
| Total | 170 | 100% |

*Source: Primary Data*

The data shows 100 % of the respondents use organic farm both from own farm and was bought from market.

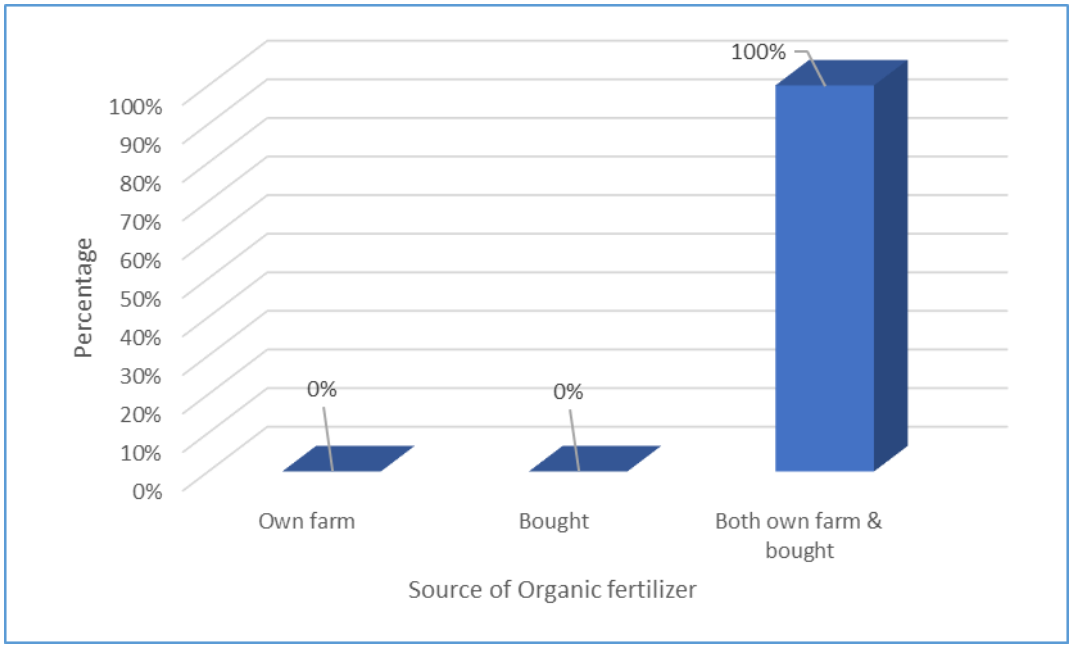



**Fig 10 : Bar graph showing percentage of source of organic fertilizer**

## 9. USAGE OF TREATED ANIMAL MANURE

The data were collected from respondents on the use of animal manure. The respondents answered on a scale of 1=Yes, 0=No.

**Table 11: Percentage of use of animal manure among respondents**

| Response | Frequency | Percentage |
|---|---|---|
| Yes | 170 | 100% |
| No | 0 | 0% |
| Total | 170 | 100% |

*Source: Primary Data*

The data shows that 170 respondents use animal manure. 100 % answered 'Yes'.

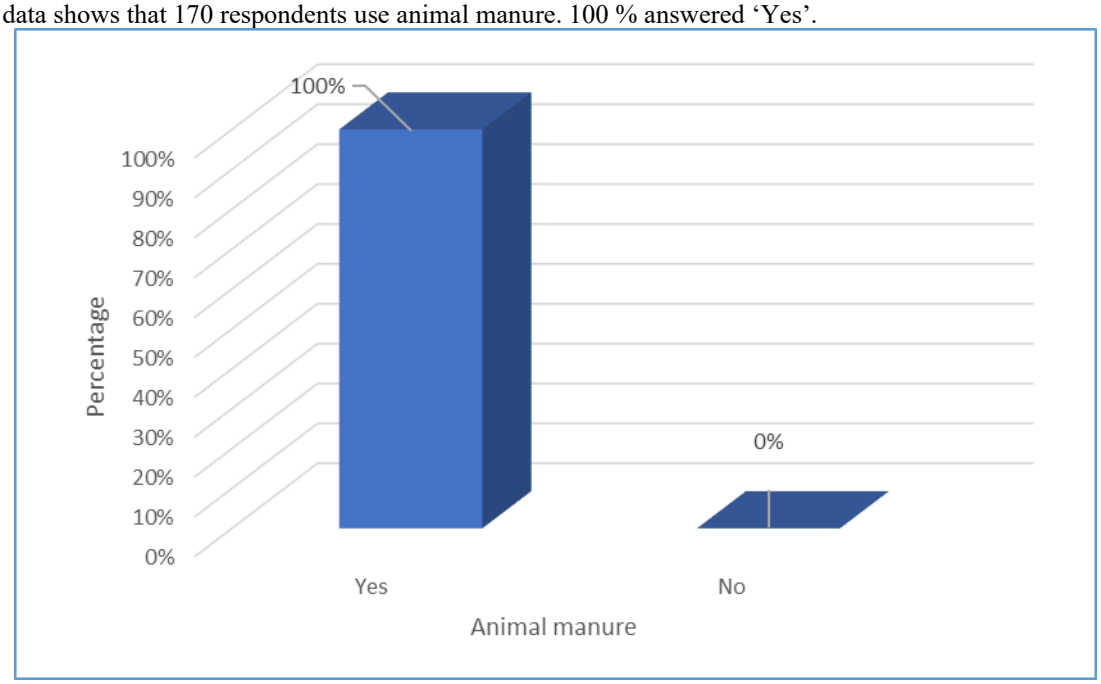



**Fig 11: Bar graph showing percentage of use of treated animal manure among respondents**

**10. TYPE OF MANUAL MANURE USED**

The data was collected regarding the type of manual manure used. The scale taken was 1=Treated, 2=Fresh, 3=Both 1 and 2

**Table 12: Percentage of manual manure used among respondents**

| Response | Frequency | Percentage |
|---|---|---|
| Treated | 0 | 0% |
| Fresh | 0 | 0% |
| Both treated and fresh | 170 | 100% |
| Total | 170 | 100% |

*Source: Primary Data*

The data shows that 100 % of the respondents use both treated and fresh manure in agriculture field.

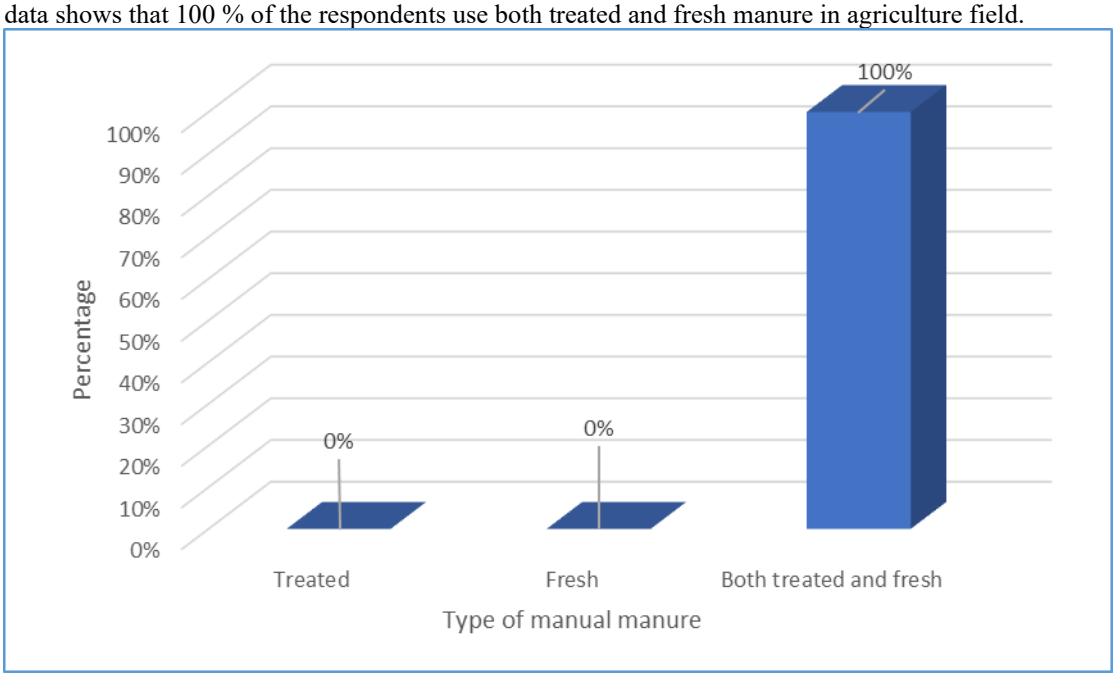



**Fig 12: Bar graph showing percentage of manual manure used among respondents**

**11. PERCEPTION OF TREATED SLURRY USE IN AGRICULTURE AND SOIL**

The data were collected regarding perception of treated slurry use in agriculture and soil fertility of rangelands, and the scale taken was 1= Positive, 0= Negative. The data was tabulated as follows:-

**Table 13 : Percentage of perception of treated slurry.**

| Response | Frequency | Percentage |
|---|---|---|
| Positive | 170 | 100% |
| Negative | 0 | 0% |
| Total | 170 | 100% |

*Source: Primary Data*

The data showed that all the respondents answered Positive. 100 % of the respondents was Positive regarding treated slurry to be used in agriculture and to improve soil fertility of agricultural land.

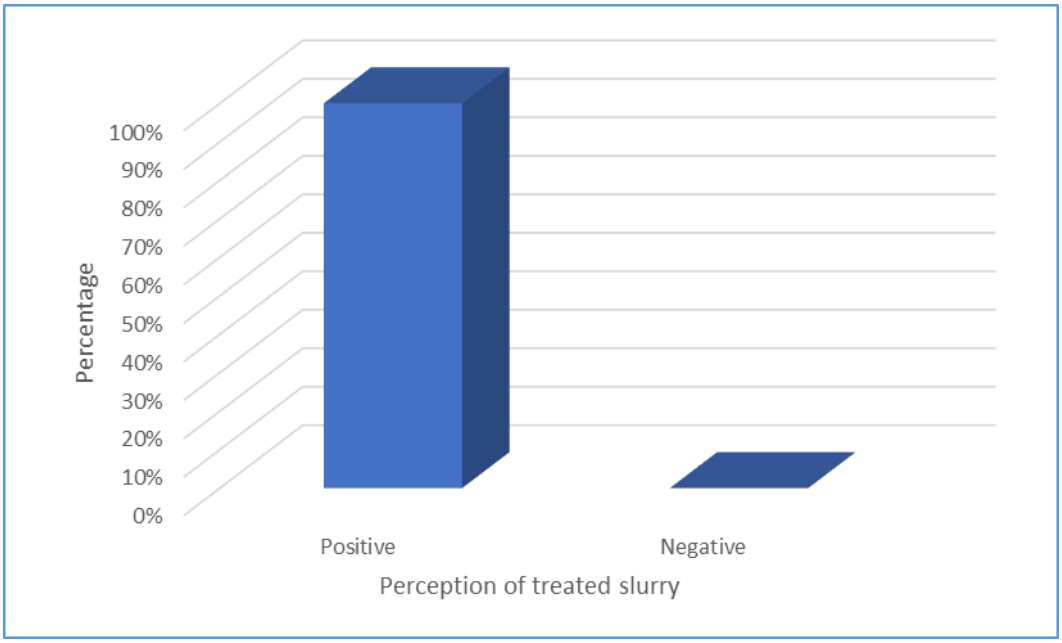



**Fig 13: Bar graph showing percentage of perception of treated slurry.**

## 12. TREATED SLURRY AS GOOD ALTERNATIVE RESOURCE AND BETTER THAN AVAILABLE EXISTING RESOURCES

The data was collected regarding response of treated slurry as good alternative and also regarding better than existing available resources. The data was collected in scale 5= Very much, 4 =Much, 3 =Do not know, 2 =No, 1 =Definitely not.

**Table 14: Percentage of response regarding treated slurry as alternative resource and better available existing resource.**

| Response | Frequency | Percentage |
|---|---|---|
| Very much | 170 | 100% |
| Much | 0 | 0% |
| Do not know | 0 | 0% |
| No | 0 | 0% |
| Definitely not | 0 | 0% |
| Total | 170 | 100% |

*Source: Primary Data*

All the respondents said they think treated slurry 'Very much' as good alternative to existing resources and as better available resources. The 100 % of the respondents marked '5'.

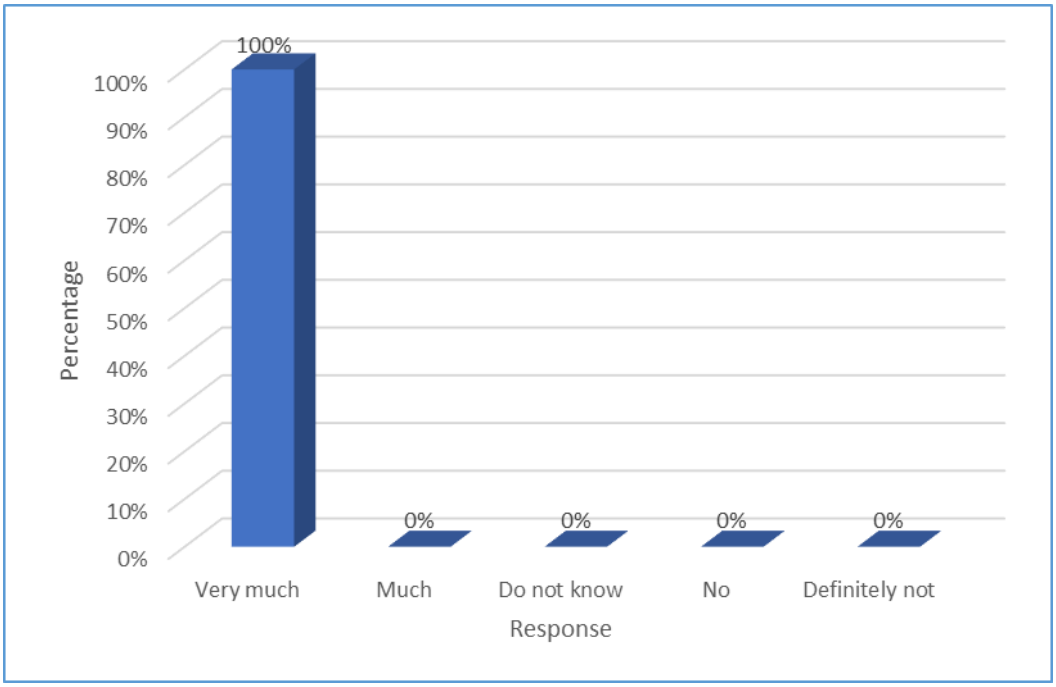



**Fig 14 : Bar graph showing percentage of response regarding treated slurry as alternative resource and better available existing resource.**

## 13. WILLINGNESS TO USE TREATED SLURRY

The data was collected on a scale of 1=Yes, 0= No. The response was tabulated.

**Table 15: Percentage showing willingness to use treated slurry.**

| Response | Frequency | Percentage |
|---|---|---|
| Yes | 170 | 100% |
| No | 0 | 0% |
| Total | 170 | 100% |

*Source: Primary Data*

The data shows that all the respondents answered Yes for treated slurry usage.

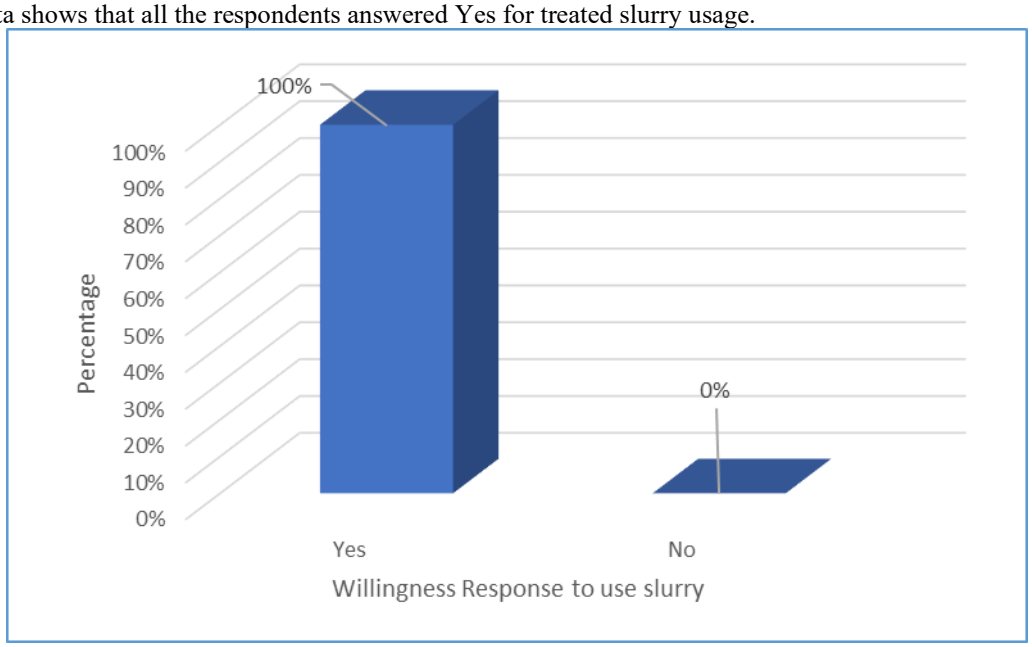



**Fig 15: Bar showing percentage of willingness to use treated slurry.**

## 14. WILLINGNESS TO USE TREATED SLURRY AS A SOIL IMPROVER

The data were taken from the respondents regarding the willingness to use treated slurry as a soil improver in agricultural land on a scale of 5. Very much, 4. Much, 3. Do not know, 2. No, 1. Definitely not.

**Table 16: Percentage of willingness to use treated slurry as a soil improver**

| Response | Frequency | Percentage |
|---|---|---|
| Very much | 170 | 100% |
| Much | 0 | 0% |
| Do not know | 0 | 0% |
| No | 0 | 0% |
| Definitely Not | 0 | 0% |
| Total | 170 | 100% |

*Source: Primary Data*

The data shows that 170 respondents answered 'Very much' willingness to use treated slurry as a soil improver in agricultural land.

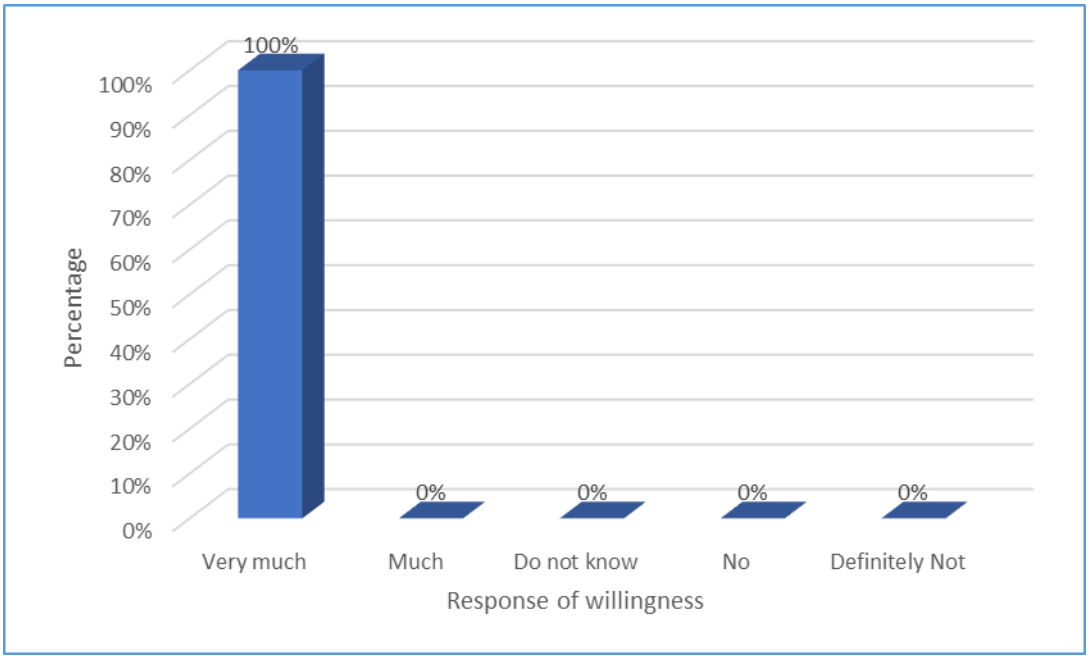



**Fig 16: Bar graph showing percentage of willingness to use treated slurry as a soil improver**

## 16. OPINION REGARDING TREATED BIO SOLIDS TO BE USED FOR ALL CROPS

The data was collected regarding treated bio solids to be used for all crops in scale 1=Yes, 0=No. And the data was tabulated as follows.

**Table 17: Percentage of willingness to use treated slurry to be used for all crops**

| Response | Frequency | Percentage |
|---|---|---|
| Yes | 170 | 100% |
| No | 0 | 0% |
| Total | 170 | 100% |

Source: Primary Data

The data shows that 100 % agreed regarding treated bio solids to be used in all crops.

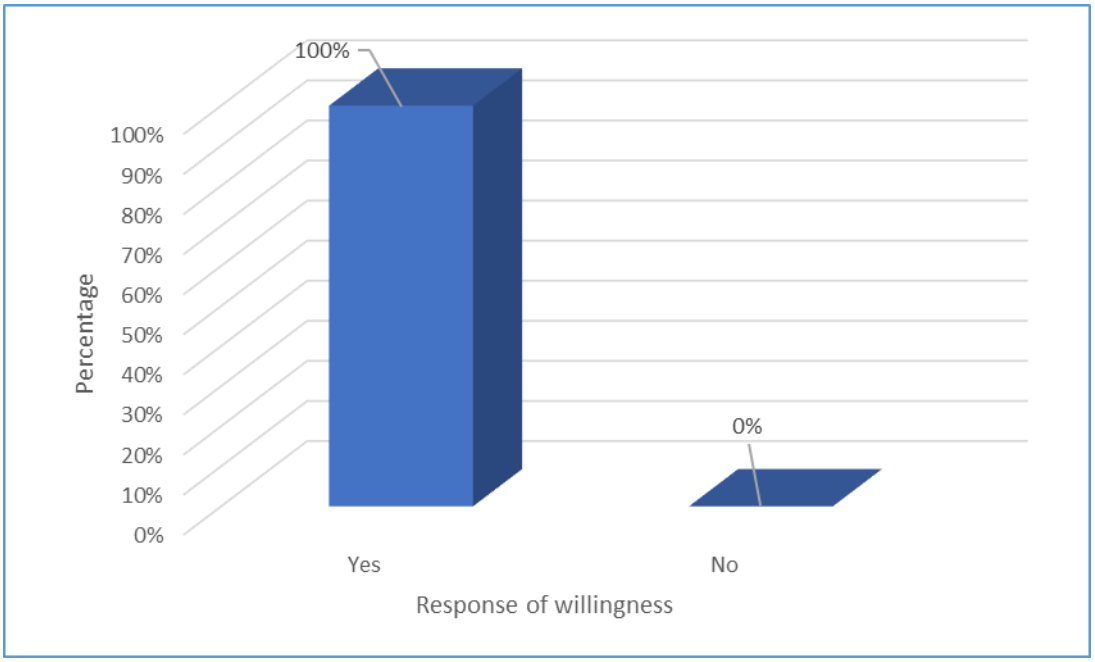



**Fig 17: Bar graph showing percentage of willingness to use treated slurry to be used for all crops**

## 17. WILLINGNESS TO PAY FOR TREATED SLURRY

The data were taken regarding willingness to pay for treated slurry on a scale of 1 = the same price as animal manure, 2= ¾ the price of animal manure, 3= ½ the price of animal manure, 4= ¼ the price of animal manure, 5= Nothing.

**Table 18 : Percentage showing willingness to pay for treated slurry**

| Response of willingness | Frequency | Percentage |
|---|---|---|
| 1 | 170 | 100% |
| 2 | 0 | 0% |
| 3 | 0 | 0% |
| 4 | 0 | 0% |
| 5 | 0 | 0% |
| Total | 170 | 100% |

Source: Primary Data

The data was captured from respondents and it shows all are willing to pay same price as animal manure. 100% of the respondents answered 1 for the payment.

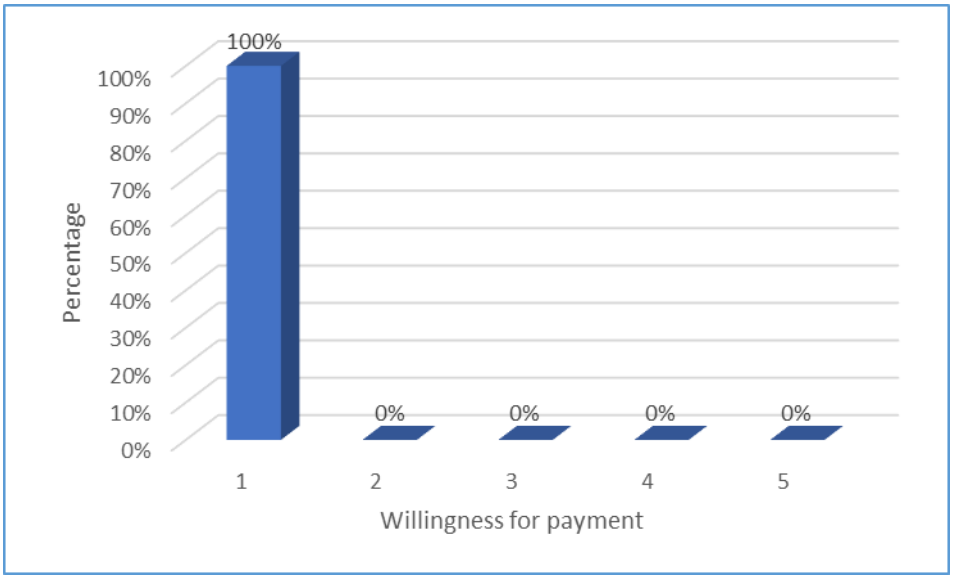



**Fig 18: Bar graph showing percentage of willingness to pay for treated slurry**

## 18. IDEA REGARDING ROLE OF FERMENTED ORGANIC MANURE IN ENVIRONMENTAL POLLUTION RESTRICTION

The data were collected on a 1=Yes and 2=No scale regarding the role of fermented organic manure in environmental pollution restriction.

**Table 19: Percentage of role of fermented organic manure among respondents**

| Response | Frequency | Percentage |
|---|---|---|
| Yes | 170 | 100% |
| No | 0 | 0% |
| Total | 170 | 100% |

*Source: Primary Data*

The data shows 170 respondents knows regarding role of fermented organic manure environmental in pollution restriction.

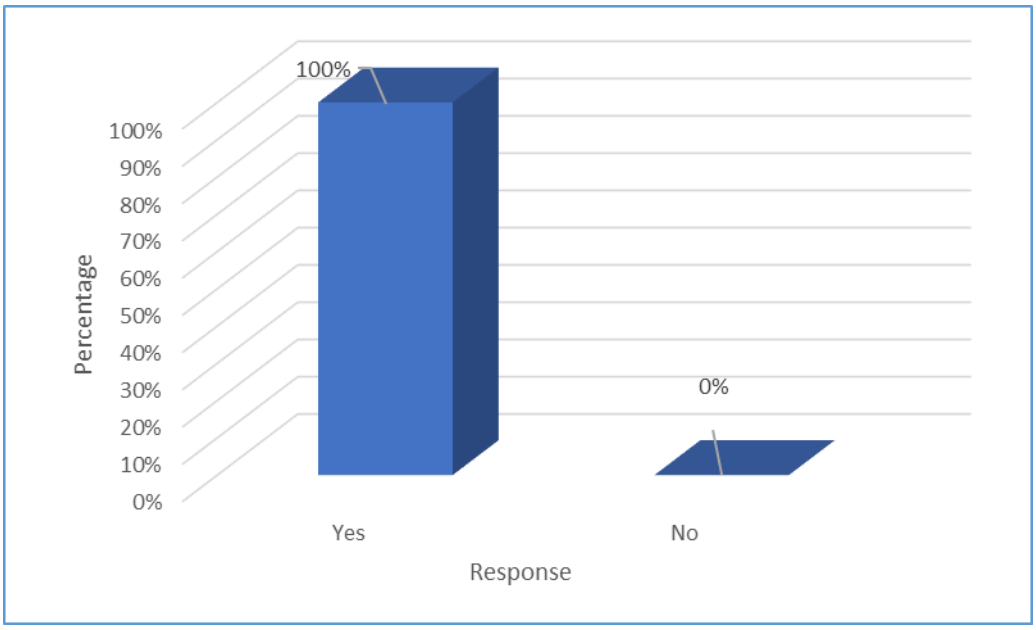



**Fig 19: Bar graph showing percentage of role of fermented organic manure among respondents**

**19. SOURCE OF FERMENTED ORGANIC FERTILIZER**

The data were collected regarding the source of fermented organic fertiliser from the respondents on a scale 1= From own farm 2= From market. The data was tabulated.

**Table 20: Percentage of source of fermented organic fertilizer from the respondents**

| Source | Frequency | Percentage |
|---|---|---|
| From own farm | 170 | 100% |
| From market | 0 | 0% |
| Total | 170 | 100% |

The data shows that all 170 respondents have taken fermented organic fertiliser from their own farm.

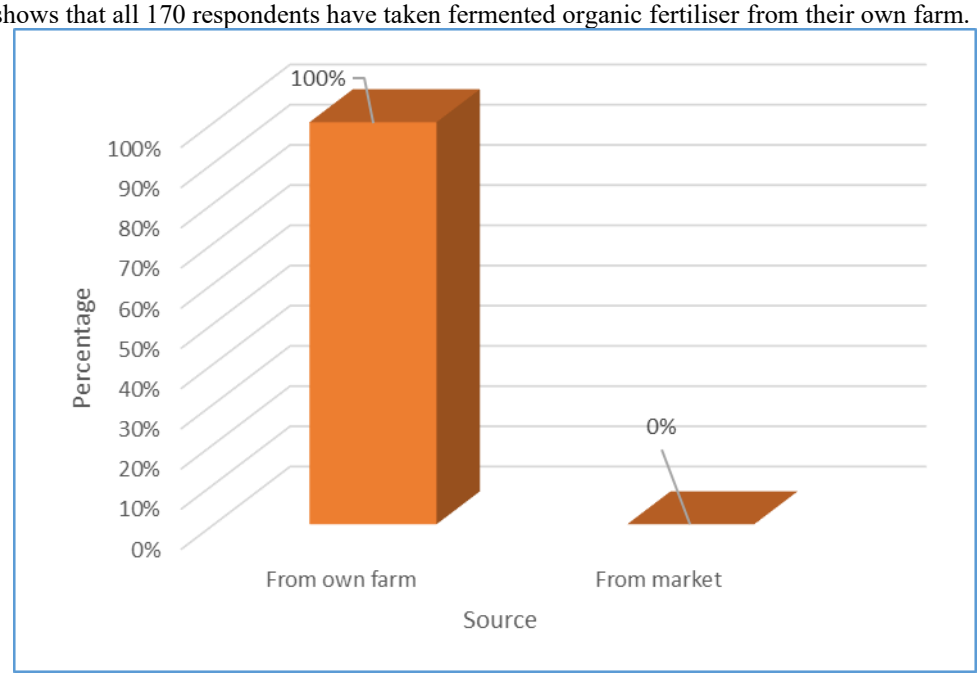



**Fig 20: Percentage of source of fermented organic fertilizer from the respondents**

**20. TYPE OF ORGANIC FERTILIZER MADE**

The data was collected from the farmers regarding the type of organic fertilizer made by the respondents.

**Table 21: Percentage regarding type of organic fertilizer made among respondents**

| Source | Frequency | Percentage |
|---|---|---|
| Plant residues | 0 | 0% |
| Solid Manure | 170 | 100% |
| Livestock slurry | 0 | 0% |
| Total | 170 | 100% |

The data show that the manure produced is mostly solid, as reported by 170 respondents.

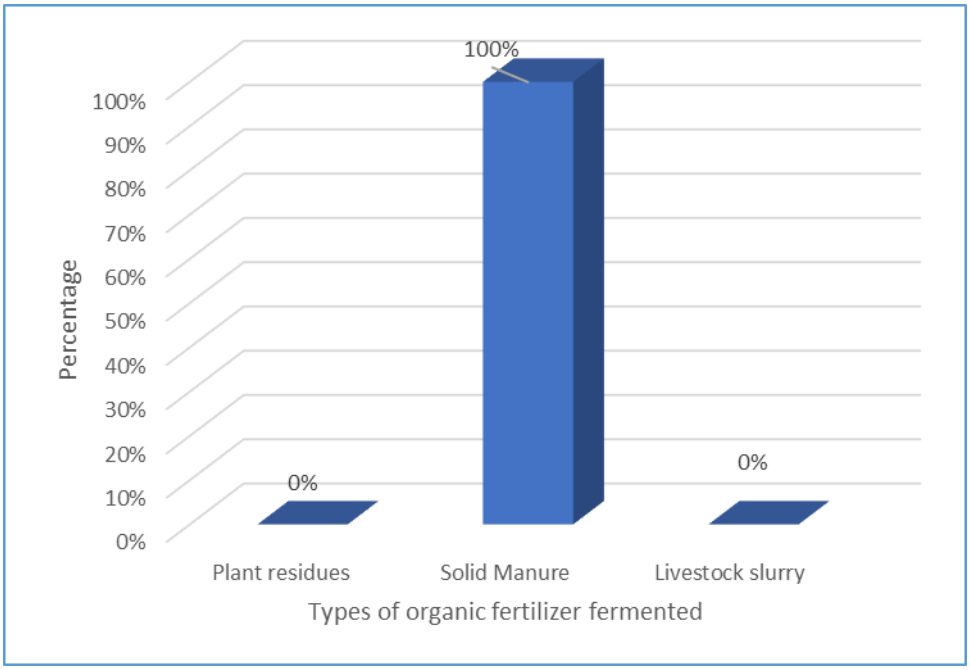



**Fig 21: Bar diagram showing types of organic fertilizer fermented**

## CONCLUSION:

An approach to rural development that is both sustainable and transformational is highlighted in the research that was conducted on the socio-economic development of women farmers in the Sundarban region through the management of manure that was based on biogas slurry. Not only does the combination of biogas technology with organic farming practices address environmental issues, but it also makes a substantial contribution to the empowerment of women in the agricultural sector.

According to the findings, biogas slurry, which is a by-product of the production of household energy, can be utilized as an extremely efficient organic manure, hence raising crop yields, lowering reliance on chemical fertilizers, and improving soil fertility. It is as a result of this that agricultural output has increased, which has, in turn, contributed to an increase in the income levels of female farmers.

Furthermore, the implementation of this environmentally friendly manure management method has resulted in significantly improved health outcomes as a consequence of less exposure to potentially hazardous chemical inputs. In addition to this, it has helped women develop a sense of self-sufficiency and the ability to make decisions, which has contributed to the promotion of gender equality in rural homes.

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