

# GENG-8000 Engineering of Technical Communication

*EFFECTS OF NITROGEN CYCLE*

# SUBMITTED TO: DON BOURNE

**SUBMITTED BY:**

**TEAM 7**

|  |  |  |
| --- | --- | --- |
| **Babal Preet** |  | **104957242** |
| **Bhavana Edara** |  | **105111357** |
| **Islam Elmas** |  | **104908361** |
| **Kartikkumar Pandya** |  | **105165019** |
| **Sai Manohar Veerubhotla** |  | **104981159** |
| **Saurav Subham** |  | **104871034** |

**Executive Summary**

Gaze upward into the sky and you glance through a huge number of air particles, 80% of which are nitrogen particles - two atoms of nitrogen bonded together. Nitrogen is discovered everywhere throughout the planet, not simply in the sky. It is in living things, air, water, even creature squander. It goes among living and non-living pieces of our planet by means of a procedure called the nitrogen cycle, which is one of the Earth's biogeochemical cycles.

As people change the manner in which we live on the planet, the manner in which that nitrogen moves around the Earth also changes. Recent changes in the nitrogen cycle are causing a truly discernible impact on common habitats and human wellbeing. Lakes are clogged with aquatic weeds. Dead zones have formed in the area of the oceans where creatures cannot survive. Air toxins that contain nitrogen are diminishing air quality and ozone-harming substances that contain nitrogen are becoming more common.

As proposed in our project introduction, we are meaning to decrease the measure of nitrogen oxide in the environment and improve the general nature of air, water, and soil in the Windsor-Essex Region.

We decided to propose Organic farming as the primary solution to reduce the levels of pollution in the Windsor-Essex Region. This proposed solution is going to take approximately 4 months. Cost estimation is done in Canadian dollars for 1 acre of land. Assumed Operating Expense Ratio is 37.1%, Return on Investment (ROI) is 49.2% and Estimated Return on Asset (ROA) is 10.26% [11]. Implementing organic farming will reduce the percentage of pollution in the ecosystem by a significant amount as it involves no usage of fertilizers.

**Table of Contents**

1. [Introduction 5](#_TOC_250031)
2. [Background and literature review… 8](#_TOC_250024)

[2.1 Background Information 8](#_TOC_250023)

* 1. [Literature Review 8](#_TOC_250022)
     1. [Effects of plant density on intercropped wheat and field beans in an organic farming system 8](#_TOC_250021)
     2. [Adaptability of organic farming of lentil varieties developed from conventional breeding programs 8](#_TOC_250020)
     3. [Soil inorganic-N and nitrate leaching on organic farms 8](#_TOC_250020)

1. [Requirements and criteria 9](#_TOC_250018)
   1. [Solution requirements 9](#_TOC_250017)
   2. [Criteria for success 9](#_TOC_250016)
2. [Design solutions 10](#_TOC_250015)
   1. [Organic Farming 10](#_TOC_250014)
   2. [Design procedure 10](#_TOC_250012)
   3. [Full conversion to organic farming… 13](#_TOC_250011)
   4. [Limitations 14](#_TOC_250010)

[4.5 Benefits to stakeholders 14](#_TOC_250009)

1. [Cost analysis 15](#_TOC_250008)

[5.1 Fixed cost 18](#_TOC_250007)

* 1. [Other assumptions 18](#_TOC_250006)
  2. Profitability, Breakeven Analysis Formulas 18

1. [Timeline 20](#_TOC_250001)
2. Conclusion and Recommendations… 21
3. [References… 22](#_TOC_250000)

## List of Figures

Figure 1 Windsor skyline 5

Figure 2 Mulching. 11

Figure 3 Intercropping 11

Figure 4 Composting… 12

Figure 5 Green manufacturing 12

Figure 6: Terraces and soil bunds 13

## List of Tables

Table 1: Organic crop production costs guidelines 15

Table 2: Profitability analysis 16

Table 3: Breakeven Analysis 17

Table 4: Seed. 18

# Introduction

Nitrogen is everywhere! Yes, you read it right. Nitrogen is present as N2 gas, and it alone occupies 78% of the Earth’s atmosphere by volume. The percentage of nitrogen in the air is far more than that of [1] Oxygen, which is only 20%. Neither our human body nor a plant or any animal for that matter can process N2 into a usable form. Neither of the living as mentioned above organisms possesses the right enzymes to capture and fix atmospheric nitrogen. In the natural world, nitrogen comes from bacterial microorganisms and that is how our human body contains quite a bit of nitrogen. The same bacterial organisms which reside in the roots of a plant use enzymes and are responsible to convert atmospheric nitrogen into a form (called fixed nitrogen) which the plants can use as nutrients. This whole process is termed as fixation. Plants then convert the fixed nitrogen into organic nitrogen. Nitrogen cycle plays a crucial role in making food. Trees quotation nitrogen [1] from the air to make food. For human, nitrogen is an important element. It is a vital element of amino acids, which can help to build blocks of proteins and DNA [2].

**A map with text

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Fig. 1. The nitrogen cycle; (1) uptake of nitrogen by plants from the atmosphere, (2) uptake of ammonium and nitrate by plants from soil and water, (3) ammonification, (4) nitrification, (5) denitrification, (6) nitrate immobilization by soil sorption, (7) nitrate leaching from the soil, (8) release of ammonia (NH3), gaseous nitrogen and nitrous oxide to the atmosphere [10].

**In general, the nitrogen cycle has five steps:**

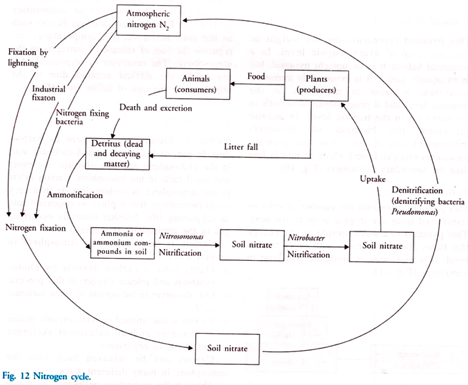
1. *Nitrogen fixation* (N2 to NH3/ NH4+ or NO3-)

2. *Nitrification* (NH3 to NO3-)

3. *Assimilation* (Incorporation of NH3 and NO3- into biological tissues)

4. *Ammonification* (organic nitrogen compounds to NH3)

5. *Denitrification* (NO3- to N2)



According to Ontario’s annual air quality report, for ground-level ozone, Windsor is one of the worst places among the whole of Ontario. According to that report, in the last 20 years, yearly mean ozone increases around 55 percent and 59 percent at downtown Windsor and West Windsor respectively, which is similar growing trends with downtown Hamilton and Toronto. A current study found that downtown Windsor’s ozone could meet the condition of Canadian Air Quality Standards but, because of transboundary flow from the U.S, it could not be possible [3].

Air pollution can create a detrimental effect on human health, such it can be challenging to take a proper breath for the person who has a problem because of either throat or lung impatience. Air pollution can affect people who have heart, lung and diabetic related disease, children, elder, pregnant women, and on people when they do any outdoor activity such as physical activity [4].

# 

1. **Background and Literature Review**
   1. **Background Information**:
2. **Eutrophication**: is a process that occurs naturally over centuries as lakes ages, besides it is characterized by the excessive growth of algae and plants. In addition, it has the most significant impact in growing of dense blooms of harmful phytoplankton that decreases water clarity. Algal blooms prevent the penetration of air into the water, reducing the growth and occasionally the death of aquatic species which can be noticed clearly in Lake Erie in Windsor [5].
3. **Factories:** Lake Erie is surrounded by heavy industries and factories, where pollutants are dumped into the lake and waterways that flowed into it without the government supervision. As contaminants increased in the water, the level of phosphates and nitrogen increased, causing the growth of algal blooms and reducing Oxygen levels in the water, thus killing more form of life such as fishes [6].
   1. **Literature Review:**
      1. **Effects of plant density on intercropped wheat and field beans in an organic farming system.**

In 1987, 88 field studies near Pang Bourne, England, wheat (Triticum aestivum) and field beans (Vicia faba) were cultivated as sole crops and additive intercrops in organic farming land. For conventionally cultivated plants, the sole crops were cultivated at 25, 50, 75, 100 and 150% of the recommended density (RD). The intercrops consisted of all combinations of the density of wheat and beans from 25% to 100% RD.

The experiment showed that Sole cropped grain yield improved as their density increased. However, the highest grain yield was achieved at 100% RD, indicating that the optimum grain yield for organic and conventional grown crops is similar. In addition, it was shown both crops could be harvested separately mechanically using the combining harvester machine, and thus this system is ideal for mechanized agriculture system [7].

* + 1. **Adaptability to organic farming of lentil (Lens culinaris Medik.) varieties developed from conventional breeding programs.**

The growth of organic farming has increased the demand for organic farming capable of organic farming crop varieties. Most species currently grown in organic farming have been produced through breeding programs. The current research focused on studying the adaptability of these varieties created by breeding programs to lentil organic farming technologies. From 2005 to 2007, 20 species were assessed in 5 different environments under organic and conventional farming systems.

The results showed that organic farming requirements for best output could be met by variants created under conventional breeding programs [8].

* + 1. **Soil inorganic-N and nitrate leaching on organic farms.**

Nitrate and Ammonium were monitored for 2 years on two organic farms in the surface layer of the soil. Nitrate was being measured according to different depths and time during the 2 years. In soil under leys, the experiment showed that the concentration of nitrate was equal to that of ammonium in both 0-7.5 cm and 7.5-15 cm layers and changing was not observed during the 2 years. However, under cereal crops, nitrate concentration was less than that of the ammonium especially in June, July, and August [9].

# Requirements and Criteria:

* 1. **Solution requirements:**
     + 1. Using innovative techniques to overcome the problem.
       2. Instead of conventional farming, organic farming is introduced:
* Cheaper because farmers do not have to purchase chemicals and fertilizers.
* Protecting the environment, mainly the quality of water, from eutrophication.
* Helping livestock to be raised in a suitable way.
  + - 1. The solution must be logical and can be implemented using the available resources.
  1. **Criteria for success.**

1. The effectiveness of the solution in eliminating the problem.
2. The total cost of the project is reasonable and affordable.
3. Raising the awareness about the problem and convincing farmers to switch into organic farming.

# Design solutions

* 1. **Organic Farming:**

Organic Farming is one of the most prominent and eco-friendly methods of producing both crop and livestock without using any fertilizers, pesticides, antibiotics and genetically modified organisms.

We decided to propose Organic farming as the primary solution to reduce the levels of pollution in Lake Erie. The reason behind proposing the solution: Lake Erie remained to be a dump yard of nutrient loads ever since the 1960s. Nevertheless, to state these nutrient loads are a result of overly fertilized agriculture lands around Lake Erie. One can easily understand the severity of pollution caused by agricultural lands in Lake Erie by going through a recent endorsement on a plan to reduce nutrient loads reaching Lake Erie, made by the United States Environmental Protection Agency (EPA) which was signed by Ontario, Ohio, and Michigan provinces. The provinces agreed to reduce nutrient loads reaching Lake Erie by 40% by 2025.

Organic farming helps to decrease the percentage of pollution caused in lake Eerie by a significant amount as it involves no usage of fertilizers, the obvious source of nutrient loads.

Organic farming consists of a five-step approach. The following are the five principles on which organic farming is usually built.

* Conversion of conventional land to Organic land.
* Proper management of the surrounding system in order to maintain biodiversity and sustainability of the system.
* Production of crops through alternative sources of nutrients
* Management of weeds and pests by the biological control system and physical means.
* Maintenance of livestock in harmony with the organic concept and also make them an integral part of Organic farming.
  1. **Design Procedure:**

Based on the above principles, Organic farming can be initiated, and the process is divided into different stages as follows [9].

1. Mulching
2. Intercropping
3. Composting
4. Green Manuring
5. Organic pest management
6. Appropriate seats and planting material
7. Planting of leguminous trees
8. Growing farm own animal feeds
9. Terrace and soil bunds
10. **Mulching:** Mulchingis the process of protecting the soil from weeds by covering the soil with dead plant materials. It is very much useful in annual crops [9].

A path with trees on the side of a dirt field

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Figure.2 mulching

1. **Intercropping:** Intercropping is the process of growing two annual crops together in alternate rows to diversify production and maximize benefits from the land. Special attention must be paid to avoid competition between the crops for light, nutrients, and water.

A close up of a green field

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Figure.3. intercropping

1. **Composting:** Composting requires very low investments by farmers. It is the process in which plant materials and animal manures are used to produce stuff required to make the land fertile and thereby leading to high yields in crops.

A group of people in a field

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Figure.4 composting

1. **Green manuring:**  It is the process of growing a leguminous plant species for biomass production and incorporation into the soil. This practice can greatly help to improve soil fertility.

A person that is standing in the grass

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Figure.5 Green manufacturing

1. **Organic pest management:** Organic pest management can be best achieved through a proper pest and predator balance. It is one of the best ecological approaches. The choice of resistant varieties of crops should be given the highest importance. Also, it is best to choose proper sowing times in order to prevent pest outbreaks. Usage of physical barriers to prevent insects, birds, and animals from reaching the crop. Pheromone attractants can be useful to trap pests.
2. **Appropriate seeds and planting material:** Healthy seed and planting materials play a great role in crop production. So, locally adapted seeds and planting materials are given first priority due to their resilience to local conditions.
3. **Planting of leguminous trees:** Besides providing fodder for livestock, leguminous trees such as calliandra and sesbania when grown with perennial crops like banana, coffee provide shade, nitrogen through nitrogen fixation and mulching material thereby improving the growing conditions of the fruit crop. Special care needs to be taken on the spatial requirements of the tree crops.
4. **Growing farm-own animal feeds:** It is necessary that animal feed must be of organic origin and the organic feed sources best served by considering farm-grown feed like grasses and leguminous fodder crops in rotation with other crops.
5. **Terraces and soil bunds:** Soil conservation is the single important thing to be given utmost importance. To prevent soil erosion, farmers should construct terraces and soil bunds along the curves. This practice builds the foundation for improving soil fertility on slopes.

A close up of text on a white background

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Figure.6. Terraces and Soil Bunds

* 1. **Full conversion to Organic Farming:**

After consistent application of all the above-mentioned techniques, with due time farmland can be fully converted into an Organic Farm.

* 1. **Limitations:**
* Limited access to safe, effective, pest control options.
* Reliance on tillage.
* Dependency on animal agriculture to both improve and maintain the fertility of the land.
* Inability to use precision fertilization.
* The soil will take time to regain its nutritional content.
* Monoculture still requires a lot of manual inputs in order to keep them producing.
  1. **List of Stakeholders:**
     + - Farmers
       - Consumers
       - Retailers
       - Residents of Windsor-Essex region and Detroit
       - Local communities
       - Wenders
       - Government
  2. **Benefits to stakeholders:**
     + - Organic farming allows for specialization opportunities.
       - It supports a healthier soil and also supports pollinators.
       - It can be implemented in almost any geographic location and in any growing season.
  3. **Suggested land for farming in Windsor-Essex County:**
     + - Harrow
       - Colchester
       - McGregor
       - Stony Point
       - Saint Joachim
       - Tilbury
       - Comber

# 5. Cost Estimation

The accompanying spending plans are estimates of the expense of creating the most commonly grown organic field crops in the Windsor-Essex region. General Manitoba Agriculture proposals are assumed for crop fertility management. These figures give a monetary assessment of the harvests and evaluated yields required to spread all expenses. Expenses incorporate labor, investment, and devaluation, however, don't incorporate administration/management costs, nor do they necessarily represent the average cost of organic production in the Windsor-Essex region.

These financial limits might be balanced by putting in client’s own figures. As a producer, you are urged to figure your very own expenses of production for different harvests. On each farm, expenses and yields vary because of soil type, atmosphere, and agronomic practices [11].

***NOTE:*** *This spending limit is just a guide and isn't proposed as a top to bottom investigation of the expense of a generation of this industry. Translation and utilization of this data is the obligation of the client.*

**Organic Crop production Costs Guidelines (Canadian Dollars per Acre)**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Operating costs** | **Brown Flax** | | **Green peas** | **Soybeans** |
| Seed and treatment | $48.21 | | $50 | $75.60 |
| Fertility | $89.77 | | $89.77 | $89.77 |
| Compost | $12.23 | | $12.23 | $12.23 |
| Herbicide | $0.00 | | $0.00 | $0.00 |
| Fungicide | $0.00 | | $0.00 | $0.00 |
| Insecticide | $0.00 | | $0.00 | $0.00 |
| Fuel | $17.50 | | $17.55 | $17.50 |
| Machinery operating | $10.00 | | $10.00 | $10.00 |
| Machinery lease | $0.00 | | $0.00 | $0.00 |
| Rental and custom | $0.00 | | $0.00 | $0.00 |
| Crop insurance | $21.12 | | $12.20 | $17.87 |
| Hail insurance | $5.12 | | $10.24 | $7.68 |
| Other costs | $7.75 | | $7.75 | $7.75 |
| Certification cost | | $3.33 | | $3.33 | $3.33 |
| Land taxes | $15.00 | | $15.00 | $15.00 |
| Drying Costs | - | | - | - |
| Interest on operating | $5.75 | | $5.70 | $6.42 |
| **Total operating** | **$235.79** | | **$233.77** | **$263.15** |
| **Fixed Costs** | **Brown Flax** | **Green Peas** | | **Soybeans** |
| Land investment costs | $64.68 | $64.68 | | $64.68 |
| Machinery Depreciation | $43.29 | $43.29 | | $43.29 |
| Machinery Investment | $11.91 | $11.91 | | $11.91 |
| Storage costs | $2.17 | $2.80 | | $2.10 |
| Total Fixed | $122.04 | $122.67 | | $121.97 |
| Total operating and fixed | $357.83 | $358.28 | | $385.12 |
| C. Labour | $64.00 | $64.00 | | $64.00 |
| **Total costs** | **$421.83** | **$421.44** | | **$449.12** |

**Profitability Analysis**

|  |  |  |  |
| --- | --- | --- | --- |
| **Estimated farmgate** | **Brown Flax** | **Green Peas** | **Soybeans** |
| Target price $per unit | $36.00 | $17 | $27 |
| Target yield per acre | 15.5 | 20.00 | 15.00 |
| Unit type | bu | bu | bu |
| Gross revenue/acre | $558 | $340 | $440 |
| Revenue ranking | 4 | 8 | 7 |
| Operating Expense ratio | 42.3% | 68.8% | 65.0% |

|  |  |  |  |
| --- | --- | --- | --- |
| **Marginal returns** | **Brown Flax** | **Green peas** | **Soybeans** |
| Over operating costs | $322.21 | $106.23 | $141.85 |
| Over operating and fixed costs | $200.17 | $16.44 | $19.88 |
| Over total costs  (Net profit) | $136.17 | $80.44 | $44.12 |
| Profitability ranking | 4 | 8 | 7 |
| Return on investment | 32.28% | 19.13% | 9.82% |
| Return on asset | 7.97% | 1.29% | 2.39% |

**Breakeven Analysis**

|  |  |  |  |
| --- | --- | --- | --- |
| **Breakeven Price Per Unit** | **Brown Flax** | **Green Peas** | **Soybeans** |
| Over Operating Costs | $15.21 | $11.69 | $17.54 |
| Over Operating & Fixed Costs | $23.09 | $17.82 | $25.67 |
| Over Total Cost | $27.21 | $21.02 | $29.94 |
| **Breakeven Yield (Bu or lb.)** |  | | |
| Over Operating Cost | 6.5 | 13.8 | 9.7 |
| Over Operating & Fixed Costs | 9.9 | 21.0 | 14.3 |
| Over Total Costs | 11.7 | 24.7 | 16.6 |
| **Breakeven Yield Risk Ratio** | 132% | 81% | 90% |

|  |  |  |  |
| --- | --- | --- | --- |
| **Agri-Insurance** | **Brown Flax** | **Green Peas** | **Soybeans** |
| 80% Insured Value | $190.94 | $231.66 | $292.04 |
| Premium Costs (% of Insured) | 11.1% | 5.3% | 6.1% |
| **Costs not Covered by Agri-Insurance** | | | |
| Operating Costs | $44.85 | $2.11 | $0.00 |
| Operating & Fixed Costs | $166.89 | $124.78 | $93.08 |
| Total Costs | $230.89 | $188.78 | $157.08 |
| **Agri-Insurance Risk Ratio** | | | |
| Operating Costs | 81% | 99% | 111% |
| Total Costs | 45% | 55% | 65% |
| **Risk & Sensitivity Analysis** | Percent Market Price Change: -10%  Percent Crop Yield Change: -5% | | |
| Market Price ($ per unit) | $32.40 | $15.30 | $24.30 |
| Yields (per acre) | 15 | 19 | 14 |

**Seed**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Brown Flax** | **Green Peas** | **Soybeans** |
| Seeding Rate per Acre | 60 lb | 2.50 bu | 84 lb |
| Price per Unit | $0.80 /lb | $ 20.00 /bu | $0.90 /lb |
| Cost per Acre | $48.21 | $ 50.00 | $75.60 |

**Fixed Costs**

Land value ($/acre): $2,800

Land cost ($/acre): $64.68

Total Crop acres: 600

Machinery Investment ($/acre): $432.92

Depreciation Rate: 10.0%

Investment Rate: 2.75%

Machinery Depreciation cost ($/acre): $43.29

Machinery Investment cost ($/acre): $11.91

**Other Assumptions**

**Fuel Costs:** Includes fuel used for fieldwork, trucking in inputs and trucking out production.

**Machinery Operating Costs:** Includes costs for maintenance, repairs, licenses, and insurance.

**Other Costs:** Includes overhead expenses - hydro, telephone, accounting, buildings, supplies and insurance, etc.

**Interest on Operating**: Interest charges on operating costs are calculated at 5% for six months.

**Land Investment Cost:** Depreciation: Assumed 10% on machinery, no salvage value.

**Investment Cost:** Assumed 2.75% opportunity cost on machinery.

**Estimated Farmgate Values:** Crop prices are based on deferred delivery contract prices for fall 2018. Estimated yields are based on 60% of MASC 10 years average for Manitoba for all crops except for hemp and buckwheat at 90%

**Storage Cost:** Storage costs for each crop are based on estimated yields entered on the Summary page. Assumed a 10% depreciation cost and 2.75% investment cost.

**Profitability, Breakeven & Risk Analysis Formulas**

**Gross Revenue** = Price per unit x Yield per acre (eg. wheat: $18.00/bu x 35bu/ac = $630.00/ac) **Net Profit** = Gross Revenue - Total Cost (eg. wheat: $630.00 gross revenue - $422.28 total cost = $207.72 per acre)

**Operating Expense Ratio** = (Operating Cost / Gross Revenue) x 100 (eg. wheat: $233.51 operating expense / $630.00 total cost = 37.1%)

**Return on Investment (ROI)** = (Gross Revenue - Total Cost) / Total Cost (eg. wheat: ($630.00 gross revenue - $422.28 total cost) /$422.28 total cost = 49.2%)

**Estimated Return on Asset (ROA)** = (Margin Over Operating - Labour - Machinery Depreciation) / (Land Investment Cost + Machinery Investment Cost) (eg. wheat: ($396.49 margin - $64.00 labour - $43.29 machinery dep.) / ($2800 land cost + $432.92 machinery inv.) = 10.26%)

**Breakeven Price** = Cost / Target Yield (eg. wheat cost $422.28 / 35 bu = $12.07 per bu) **Breakeven Yield** = Cost / Price per Unit (eg. wheat cost $422.28 / $18.00 bu = 23.5 bu) **Breakeven Yield Risk Ratio** = (Yield per Acre / Breakeven Yield) x 100 (eg. wheat yield 35 bu/ac / 23.5 bu BE = 149 %)

**Agri-Insurance Risk Ratio** = (Agri-Insurance Coverage / Operating Cost) x 100 (eg. wheat coverage $178.79/ac / $233.51 operating expense = 77 %)

# Timeline

# Start Date: 20th June 2019

# End Date: 23rd October 2019

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| ID | Task | Start Date | End Date | Time Period |
| 1 | Initials | 20 June 2019 | 30 July 2019 | 10 days |
| 1.1 | Project preliminary approval |  |  |  |
| 1.2 | Background research |  |  |  |
| 1.3 | Deep study of the topic |  |  |  |
| 1.4 | Project understanding |  |  |  |
| 2 | Planning | 1 July 2019 | 10 July 2019 | 10 days |
| 2.1 | Scheduling |  |  |  |
| 2.2 | Plan baseline budget and resources |  |  |  |
| 2.3 | Research on different alternatives |  |  |  |
| 2.4 | Study of Government plans/permissions |  |  |  |
| 2.5 | Agreement to move forward with the project development phase. |  |  |  |
| 3 | Project Development phase | 11 July 2019 | 20 July 2019 | 10 days |
| 3.1 | Formalization of the project plan |  |  |  |
| 3.2 | Community consultation |  |  |  |
| 3.2 | Site Inspection |  |  |  |
| 3.4 | Capital budget planning |  |  |  |
| 4 | Capital Investment release |  |  |  |
| 5 | Implementation | 21 July 2019 | 22 Oct 2019 | 3 months |
| 5.1 | Mulching |  |  |  |
| 5.2 | Intercropping |  |  |  |
| 5.3 | Composting |  |  |  |
| 5.4 | Green manuring |  |  |  |
| 5.5 | Organic pest management |  |  |  |
| 5.6 | Appropriate seats and planting materials |  |  |  |
| 5.7 | Planting farm own animal feeds |  |  |  |
| 5.8 | Terrace and soil bunds |  |  |  |
| 6 | Project Completion and Reflection | 23 Oct 2019 | 23 Oct 2019 | 1 day |

# 6. Conclusion

By the proposed solution, we can completely reduce the involvement of Nitrogen-based fertilizers in farming and thereby reducing dumps of loads of nutrients from agriculture farms into water bodies like rivers, lakes. Organic farming techniques can bring balance in the nitrogen cycle as they involve no use of fertilizers which the main cause of disruption in the Nitrogen cycle are. As mentioned in the estimation costs, organic farming takes less capital for implementation. Assumed Operating Expense Ratio is 37.1%, Return on Investment (ROI) is 49.2% and Estimated Return on Asset (ROA) is 10.26% per acre [11].

In addition to this proposal, it is recommended that the Windsor-Essex County municipality review alternative methods of organic farming to further reduce the amount of nitrogen released into the local environment.

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