An Innovative Approach for Valorization of Areca Sheath- misplaced resource in Micro and Small-Scale Enterprises

Comprehensive Examination Report on the Research Proposal for Registration

for

Doctor of Philosophy

Submitted by

Prasannakumaran KM

2021RDZ8632

Under the guidance of

Prof Jatindra Kumar Sahu and Prof VM Chariar

Centre for Rural Development and TechnologyIndian Institute of Technology Delhi

May 2023

Introduction:

India boasts a wide range of agro-ecological features, including the world's largest mountain chain, the Himalayas, to the north, the Thar Desert to the west, the Gangetic delta to the east, and the Deccan Plateau to the south. Agriculture is critical to the Indian economy (Singh et al., 2017). Agriculture and related sector activities employ 54.6% of the entire workforce (Census 2011) and contribute for 17.8% of the country's Gross Value Added (GVA) in 2019-20. India's agriculture industry has the world's second-largest agricultural acreage, employing about half of the country's population. According to the Field Usage Data 2016-17, the nation has a total geographic region of 328.7 million ha, among which 139.4 million hectares is estimated net sowed area and 200.2 million ha is net cultivated area with a farming efficiency of 143.6%. The net sown area is 42.4% of the entire geographical area. (Hailu et al., 2018).

There are 68.6 million hectares of net irrigated land. While the Indian agricultural sector has attained grain self-sufficiency, production is resource costly, cereal-centric, and geographically biased. Indian agriculture's resource-intensive methods have also prompted severe sustainability concerns (Mukherji et al., 2008). The country's water supplies are under increasing strain, necessitating policy realignment and reassessment. Drought and land degradation are also serious hazards to farming in the nation. Total food grain output in the nation is predicted to be 144.52 million tones based on First Five - year plan period for 2020-21. The output in 2020-21 is 9.83 million tones more than the average production of food grains in the preceding five years (Kumar 2014). (2014-15 to 2018-19).As the world's population has grown, so has the need for agricultural and food products. Farmers are progressively transitioning to technologically advance modern agricultural technologies to raise agricultural production and fulfill the world's rising food demand. Intensive farming employs cutting-edge farming practices and synthetic fertilizers, resulting in significantly increased agricultural production.

Unfortunately, this leads to an increase in both biodegradable and non-biodegradable misplaced resources. With the enormous magnitude of agriculture in our country, agricultural misplaced resource creation cannot be disregarded. Every year, agricultural-based companies and farming activities generates a massive volume of residues. Especially the leftovers after harvesting like straw, sugarcane trash, areca sheath and weeds are need to manage in a sustainable manner. If these leftovers are discharged into the environment without adequate disposal, they may create pollution and have a negative impact on human and animal care. Most agro-industrial leftovers are unprocessed and unused; thus they are often disposed of by burning, dumping, or uncontrolled land filling (Dey et al., 2021). Such unprocessed misplaced resources contribute to climate change by generating a variety of greenhouse gases. Apart from that, the use of petroleum and coal has an effect on greenhouse gas (GHG) emissions. As a result, appropriate care must be taken to degrade agricultural misplaced resource using good agricultural misplaced resource management programs in the form of value addition of misplaced resources by using up cycling and recycling practices to leads the entrepreneurship journeys.

Agriculture Misplaced resource Generation:

Biomass may be categorized according to its origin, such as plantation biomass, forest biomass, industrial biomass, aquatic biomass, and so on. Wood misplaced resource and agricultural misplaced resource are the primary sources of biomass (Saidu et al., 2011). According to the Ministry of New and Renewable Energy (MNRE 2020), the Government of India, around 620 Mt of agricultural residue is created each year. India is the world's second-largest producer of agricultural misplaced resource after China, producing more than 130 million tons of paddy straw, half of which is utilized as feed and the other half is thrown. Biomass availability in India is projected to be over 500 million tons per year, including misplaced resources from agriculture, agro-industrial, forest, and plantations (Verma et al., 2014). Crop residues formation and utilization vary greatly depending on cropping intensity, yield, and crops planted in various Indian states. Uttar Pradesh generates the most residue (60 Mt), followed by Punjab (51 Mt), and Maharashtra (46 Mt) (Devi et al., 2022).

To develop specialized in-situ or ex-situ techniques for the management or treatment of a given agriculture misplaced resources, an inclusive perception of the source, quantity, and kind of resources being created is required. Crop residues, animal misplaced resource, agro-industrial misplaced resource, and aquaculture misplaced resource are the four primary categories of agricultural misplaced resources, as previously mentioned in the Fig 1.Crop residues contribute the major portion of the agricultural misplaced resources; it consists of sugarcane trash, wheat straw, rice straw, weeds and other plant residues. Agricultural residue output is presently estimated to reach 2802 Mt/y worldwide (Reddy et al., 2018). Just a small part of wheat, maize, and rice crop leftovers are used in production of bio-ethanol or animal feed worldwide. On the other hand the livestock misplaced resources contain cattle excreta and dead animals, and agro industry misplaced resources has rice husk, wheat husk and other animal peels misplaced resources. Finally, the aquaculture misplaced resource including the misplaced resource produced from the aquaculture fish excreta, fish market misplaced resource and some other metabolic misplaced resource.

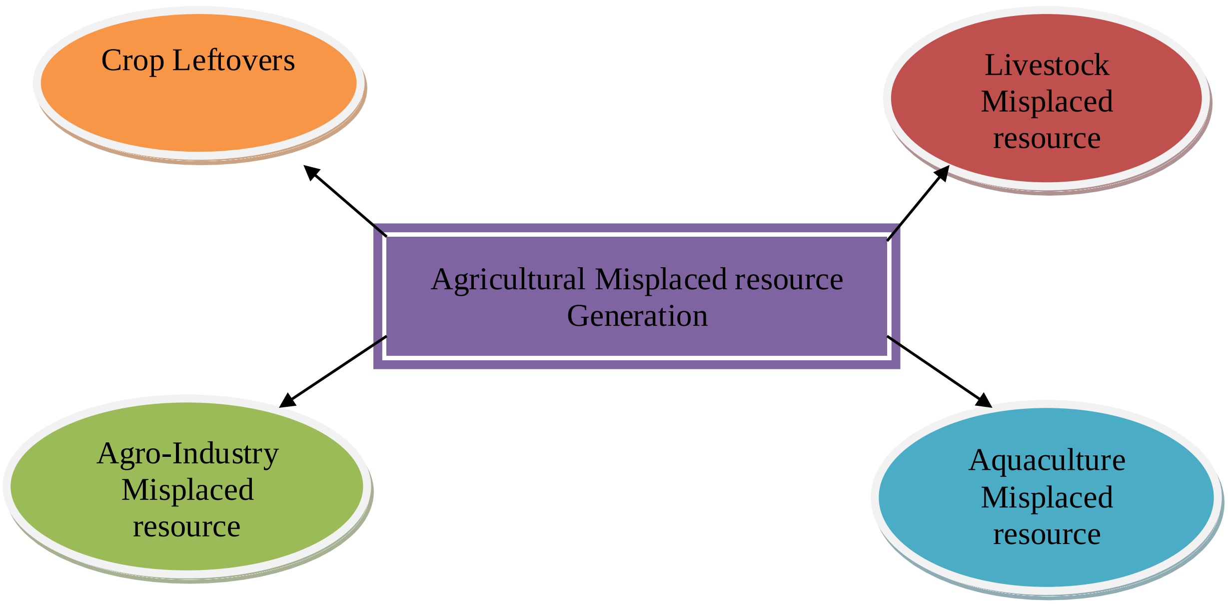


Fig1. Categories of agricultural misplaced resource generation:

Agricultural Misplaced resources from Areca nut fields:

Areca catechu L. is a major cash crop in India. The commercial output is the nut named "betel nut" and after that is employed largely for masticatory functions. Being a very valuable commercial crop, it is critical to understand and implement a set of techniques in an areca nut farm to maximize returns (WHO 2012). The areca nut palm is grown largely for its kernel, which is extracted from the fruit and eaten in its tender, ripe, or processed state. Despite its origins in the Malayan Archipelago, the Philippines, and other East Indian Islands, commercial production is limited to India, Bangladesh, and Sri Lanka (Ramappa et al., 2014). This crop is grown on around 200,000 acres of land in India, with an annual yield of 2, 28,600 tons. Kerala, Karnataka, and Assam make for more than 90% of the country's overall land and productivity. Apart from chewing, areca nut has no additional uses. Its export opportunities are likewise somewhat restricted. Areca nut husk is the outer skin of the areca fruit. It accounts for 60-80% of the overall weight and size of the berries (fresh weight basis) (Nair 2009).Apart from being an excellent source of furfural, areca nut husk is used in the manufacturing of hard boards, paperboards, pillows, and non-woven textiles (Yusriah et al., 2014). Yet, owing to cost considerations, none of these are commercially used.

The areca nut farms will have an average of 5.5-6 tons of organic misplaced resources per acre each year (Vannarath et al., 2022). Direct recycling of this trash does not instantly match crop need. The main resources for the areca based misplaced resources are areca sheath derived industries, areca nut husk, areca leaf sheaths. Every areca tree produces nearly 7 to 8 leaf sheaths annually and per acre nearly 500 to 550 trees are populated, that means approximately 4000 areca sheaths are available per year per acre. Karnataka itself owns 80 percentage of the areca nut tree population in India followed my Assam and Kerala. Based on the current cultivated area, the estimated recyclable biomass production from areca nut is about 4.5-5.4 million tons annually in India and about 9.0-10.8 million tones worldwide (Prasanna et al., 2020). According to revised estimates, the area under areca nut in 2017-18 was 496,000 ha, with an output of 833,000 tones (Kargal et al., 2022). Arecanut tree requires seven years to develop fully and can be found in the field for up to eighty years. During its life cycle, the areca nut generates the main product (betel nut) and by-products (leaf sheath and areca nut husk), however, the by-products are misplaced resourced if not effectively exploited to produce valuable commodities (Naik et al., 2010).

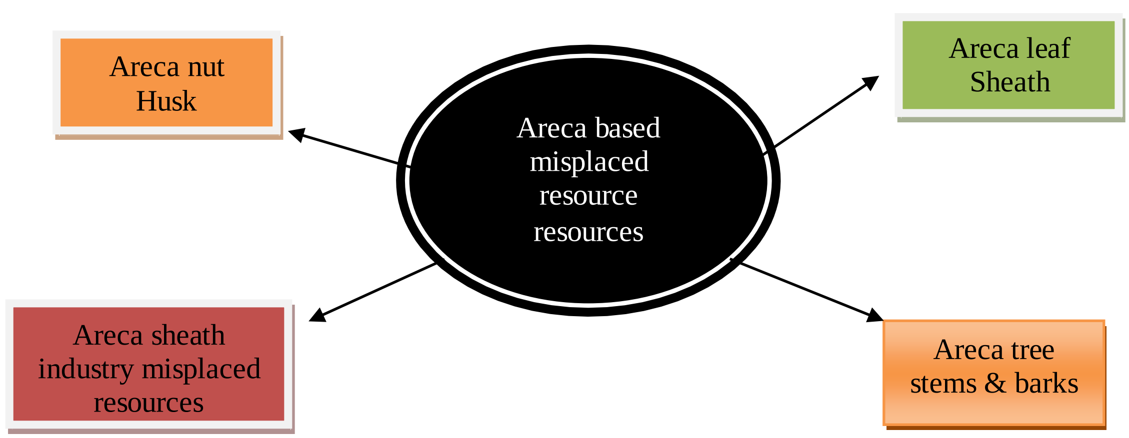


Fig2. Types of Areca farm based misplaced resource resources

Review of Literature:

Utilization of Areca sheath:

Approximately three million farmers worldwide depend on areca nut cultivation as their primary source of income, as it offers significant employment opportunities and financial benefits. Areca sheaths are mainly utilized for three purposes, they are Areca tableware making, composting and for cattle feed (Nayak et al., 2021). Rarely by using the method for producing ply boards from areca leaf sheath has been devised. These planks may be used to construct luggage, filing cabinets, and tea chests. A machine for manufacturing areca nut leaf sheath cups of various sizes and shapes is available on the market. The areca nut leaf sheath was discovered to be ideal for manufacturing ply boards. The ply boards are made with two plies of processed areca nut leaf sheaths and a core of regular wood veneer attached with urea formaldehyde resin (Annamalai et al., 2017). But the main issue in the utilization of areca sheaths are they are not uniform in size, shape and thickness. The Areca sheaths are heterogeneous in nature so difficult to utilize 100% of the areca sheath produced in the arecanut farms. The alternate use of this underutilized sheaths are mostly used for open burning or used as fuel for cooking. In some places farmers used this underutilized sheaths for vermi-compost and ordinary composting, (Maheswari et al., 2015) demonstrates that the organic sources found in the areca nut leaf sheath were broken down into nutrients by soil bacteria. The carbon nitrogen ratio of EM (effective microbes) activated compost produced from the areca sheaths are ranging from 30:1 to 65:1.

Animal feed:

(Gowda et al., 2021) reported that the cultivation of commercial crops are partially replaced the traditional cereal crops due to large amount of profit and economic returns. This has led in a dry fodder shortage, particularly in Karnataka's coastal zones, and livestock producers are forced to purchase paddy straw from neighbouring districts at a greater cost. The nutritional makeup of areca sheath was found to be quite comparable to that of paddy straw. ICAR-NIANP research has found no negative effects from feeding fresh areca sheath to livestock’s. It is advisable to use dried and shredded areca sheath in the embodiment of a complete mixed ration with a reasonable amount of concentrate cater for optimum usage (Gowda et al., 2021).

Nutrient requirement for cattle:

Cattle are natural grazers with a unique capacity to digest plant sugars that most other mammals find indigestible (Clauss et al., 2010). To sustain productivity and health, cattle require a continuous supply of calories, protein, minerals, vitamins, and water. Cattle nutritional requirements may be divided into four categories: maintenance, lactation, growth, and reproduction. Similarly, the maintenance component comprises all of the nutrients needed by the animal to breathe, move, digest food, stay warm, repair tissues, and maintain body weight. Lactation nutrient needs are determined by the volume of milk produced during peak lactation and the makeup of the milk (Hansen et al., 2012). Cattle require nearly 7 to 14% of crude protein in dry matter consumption in everyday life, but it different with dry cows and milk cows (Leonardi et al., 2003). A young female cow, particularly one that has not yet given birth (calf).require 10.5 to 14 percent protein in their dry matter consumption. Sodium chloride, phosphorus, sulphur, zinc, copper, selenium, and potassium are minerals that appear to be inadequate in cattle diets.

Fresh Areca Sheath used as cattle feed:

According to research, the chemical and nutritional compositions of areca sheath are nearly identical to those of paddy straw (Gowda et al., 2021). Some minerals, including as calcium, copper, and sulphur, are more abundant in areca sheath.

The selected paddy straw for comparison is available throughout the year and cheap in cost (Bakker et al., 2013). While compared with paddy straw, the areca sheath is rich in protein, low in lignin and nearly 50% consists of digestible nutrients. In India traditionally, paddy straw is used as dry fodder for livestock's and it is the main part of agricultural misplaced resources also.

The two graphs 3 and 4 respectively explains the minerals content, protein, NDF and ADF of areca sheath and paddy straw. The Fig 5 and 6 comprehensive the paddy straw have high tannin content while compared to areca sheath. Another graph comprehensive the areca sheath have high total digestible nutrients while compared to paddy straw.

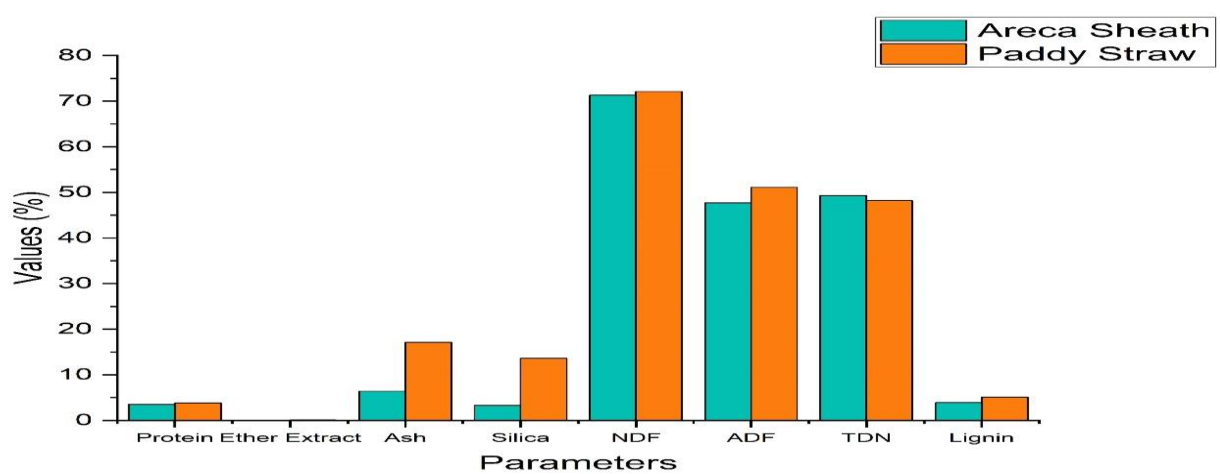


Fig3.Nutrient Profile comparison of Areca Sheath and Paddy straw (Data from Gowda et al 2021)

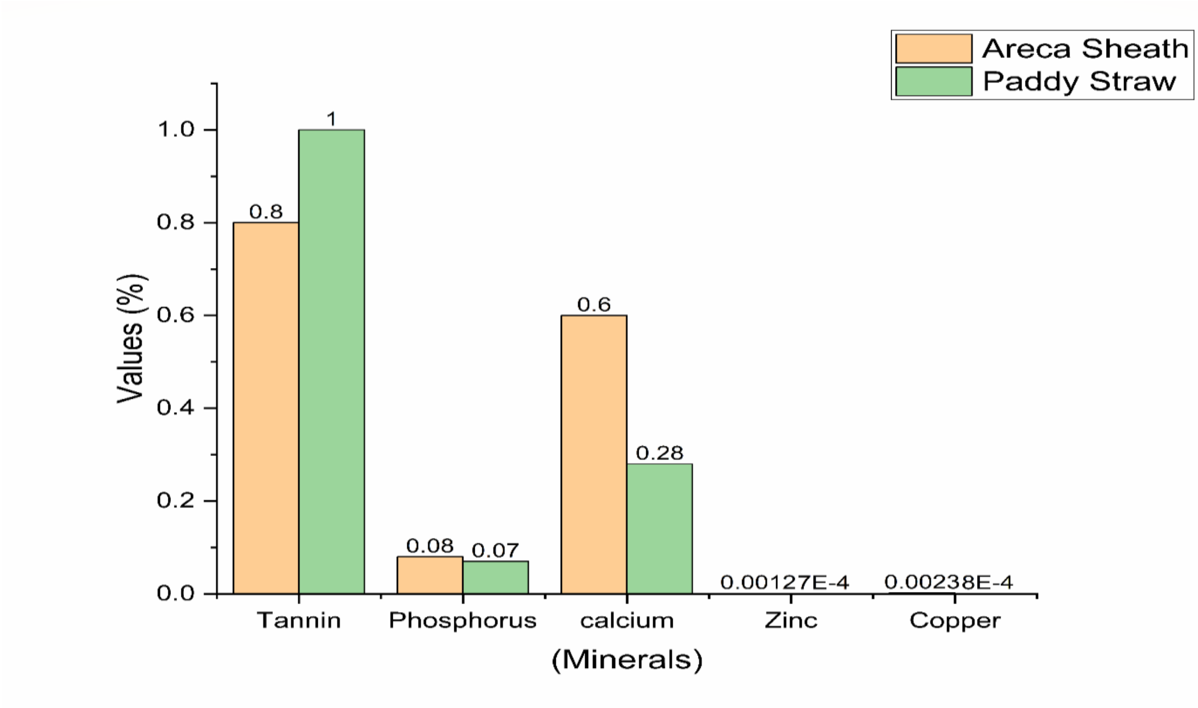


Fig 4. Mineral profile comparison of Areca sheath and Paddy straw (Data from Gowda et al 2021)

Technology used for conversion of areca sheath misplaced resources into cattle feed:

The background of the technology in the areas of Karnataka, Kerala, the Andaman and Nicobar Islands, and some north eastern states, notably along the coast, have a shortage of dry forage, thus paddy straw is bring in from nearby places, resulting in increased cater costs. Areca production as a money-oriented crop is widespread in this area, and the falling areca sheaths might be used as dry feed for dairy cows. To boost milk production, a technique was created that uses moisture free areca sheath in the form of total mixed ration together with a proper amount of concentrate. This was also confirmed at the farmer level. The apparatus necessary to prepare the areca sheath has been erected and authorized in the milk producers' cooperative society at Panaje in Puttur taluk of Dakshina Kannada district in Karnataka with the financial help of NABARD under the rural innovation fund scheme (Letha et al., 2012). Under the technical supervision of NIANP experts, dairy farmers began employing prepared areca sheath in the form of complete mixed diet, and farmer perceptions of milk output and quality are very positive.

Advantages of areca sheath as cattle feed:

- The farmers' impression of using areca sheath as a substitute to paddy straw, which is rare and expensive in some remote location, was quite positive.
- Using areca sheath rather of paddy straw results in a net cost savings of 50% when feeding dry fodder.
- According to the economics of feeding, feeding TMR with areca sheath resulted in a net savings of Indian rupee 14.4 per cow per day in the current research.

Limitations of areca sheaths are used as cattle feed resources:

Long-term feeding of a significant quantity of low-quality roughages causes rumen and omasum impaction. Ruminal impaction is a serious illness that affects ruminants. It is highly widespread in poorer nations, presumably due to unorganised small-scale farming and inadequate livestock care and feeding standards. The areca sheath also comes under the low quality forages with low protein and high fibre content. (Ravi et al., 2019) reported the case of cow with ruminal and omasal impaction.

The main reason for this complaint is with little access to water, the animal had been consuming areca sheath fibres solely for a long period. A longitudinal linear incision was made around five cm distant from the trocarised region on the surgical site, and rumenotomy was performed. Nearly the rumen contained 31.5 kg of undigested areca sheath fibres.

Ruminal impaction caused by areca fibres in a cow is an uncommon instance that can be effectively treated surgically. Reason for this ruminal impaction is not only the areca sheath, the water access also. The correct formulation and optimum water access will eliminate the impaction in cattle, the table 3 explaining the literature about areca based formulation and water access requirement of cattle.

In-Vitro Digestion studies for goats:

A work was conducted to determine the nutritional parameters of areca sheath as a dry forage pedigree for goats. Six areca leaf sheath samples were collected and analysed for proximate composition according to AOAC (1995) and expressed as a percentage of dry matter. A 30-day palatability experiment with four one-year-old goats was done to investigate the palatability of areca sheath samples. The group of 4 goats were incubated separately in a huge, well-ventilated shed with one by one feeding and watering system. As a solitary feed, all of the animals were given an unlimited quantity of grain. To measure the dry matter absorption, the weights of the areca sheath feeder and leftover were monitored, and the moisture content was assessed. Following the palatability testing, a five-day digestibility study was done to evaluate the digestibility coefficients of nutrients. The goats were tethered with faeces collecting bags during the digestibility experiment period, and faeces voided in 24 hours were collected for five days. Daily faeces, feed provided, and leftover samples were collected, pooled for each individual animal, kept, and stored for future examination. Moisture estimate was performed on fresh samples on a regular basis. The digestibility coefficients of areca sheath were 79.94, 49.69, 73.43, 88.14, and 83.19% for ether extract, nitrogen free extract, dry matter, and crude protein respectively.

Areca sheath samples digestible crude protein and total digestible nutrients were 5.44 and 67.92%, respectively. (Gowda et al., 2012) reported similar values for TDN (>50 percent) in areca sheath and also indicated that areca sheath misplaced resource is loftier to paddy in terms of lignin content, it is quite low (3%), silica (4%), higher energy (>TDN 50%), and few minerals like copper, calcium, and sulphur while cater for areca sheath as a dry fodder source in the form of total mixed ration (Anil kumar et al., 2022).

3. Research Gaps:

- **Current Use**: Currently, areca sheaths are used to produce areca-based tableware products, and they have good demand in the export market. Nevertheless, the researchers do not notify and quantify the misplaced resource produced by the areca sheath driven industries.
- **Underutilized:** The misplaced resources produced from the areca industries are abundant and underutilized natural and entrepreneurial resources in India. As per the literature survey, only fresh areca sheaths are used as dry fodder for livestock feeding, and limited research findings indicated that the areca sheath industry misplaced resources are used as cattle feed.

- **Lack of Data**: There is no scientific finding present regarding areca sheath-based industry misplaced resources. As per the data, Karnataka state has 600 small areca manufacturing units, but there is no data regarding the misplaced resource products from these industries.
- **Increased Demand**: In the future, demand for areca products will increase with decreasing usage of plastic products as they cause certain environmental problems.
- **Valorization Techniques:** If the demand increases, the production of areca products will increase and hence the amount of misplaced resource production will also increase. Since

there are no practical valorization techniques developed currently, scientific intervention for valorization of areca sheath misplaced resource is imperative.

4. Scope of research:

India is the world's leading milk producer and largest cattle population, but its productivity is poor compared to other countries. The main issue for poor productivity is the unavailability of livestock fodder. Per day buffalo requires nearly 30 kilograms of fodder. It includes 4-5 kilograms of straw and 4 kilograms of grain; the remaining is green fodder. Paddy straw is the primary type of feed for livestock in India. In recent times north India has faced a wheat crisis due to climate change issues. It directly affects paddy straw production, so costs increase yearly.

The leading cause of the paddy straw crisis is not only the climatic change; the cultivation of some other crops with high profit reduces paddy production. So the farmers need an alternative source of paddy straw during these crises. As per the reports, the excellent and sorted areca sheaths are used for plate making industry and the remaining sheaths are burned in open spaces or used as cooking fuel. If these unutilized areca sheaths are used as livestock feed with proper formulation, it holds tremendous market potential and helps in reducing the dependency on paddy straw.

5. Research Objectives:

1. **To explore untapped potential of areca sheath industry's misplaced resources and conduct characterization studies on such resources**.
   - ✓ The aim of this objective to quantify the areca sheath derived industry misplaced resource resources in all over India by using Geographical imaging system as well as field surveys.
   - ✓ Determine the physio-chemical properties of the areca sheath industry misplaced resources from different geographical locations of India.

2. **To Formulate and evaluate the novel Areca mix livestock feed**.
   - ✓ This objective is designed to prepare proper balanced areca mix nutrient feed for livestock’s. Because areca misplaced resources are rich in fiber and anti-oxidants activity, so formulation of novel feed with respect to different percentage of areca misplaced resource make the novel feed become balanced one for livestock’s purposes.

3. **To test multiple myco-toxins and Bio-Availability of novel areca mix livestock feed**.

- ✓ The above objective will focus on the estimation of myco-toxins in the areca sheath industry misplaced resource as well as formulated novel feed. Myco-toxins estimation plays a vital role in the feed production, because our targeted resources are considered as misplaced resources in the industry.
- ✓ In vitro studies to estimate the bio-availability of the novel areca mix feed and animal voluntary intake of novel areca mix feed.

4. **To frame the Business model for rural youths by using novel Areca mix feeds for livestock**

- ✓ This Objective will focus on generating rural employment through selected novel areca mix nutrient feed and designing supply value chain for areca sheath industry misplaced resources.
- ✓ Evaluation of shelf life analysis and market response study of formulated product.

6. Proposed Methodology:

Objective 1: To explore untapped potential of areca sheath industry's misplaced resources and conduct characterization studies on such resources.

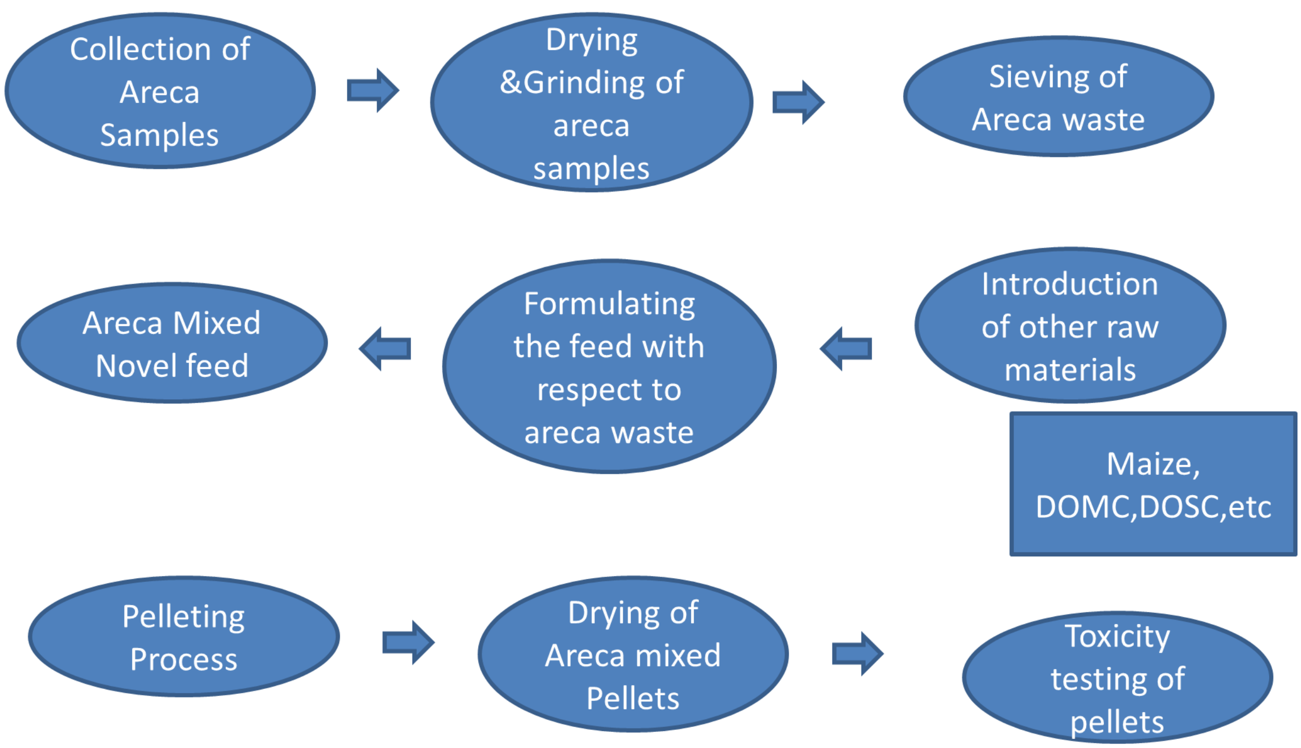
- ✓ To visualize the areca nut tree growing areas and location of areca sheath derived industries in the form of maps i.e. resource maps and study maps.Quantify the areca sheath derived industry misplaced resource resources in all over India by using Geographical imaging system as well as field surveys.
- ✓ **Characterization studies of Areca Sheath misplaced resource**:
- ✓ The goal of chemical characterization is to identify and quantify the chemical constituents of a material and to help establish its biocompatibility.

Objective 2: To Formulate and evaluate the novel Areca mix livestock feed.

- ✓ By determining volumes of ingredients and additives to blend in order to create compound feeds that meet the known nutrient requirements of targeted species and achieve production goals at an optimized cost.
- ✓ To prepare proper balanced areca mix nutrient feed for livestock's. Because areca misplaced resources are rich in fiber and anti-oxidants activity, so formulation of novel

feed with respect to different percentage of areca misplaced resource make the novel feed become balanced one for livestock's purposes.

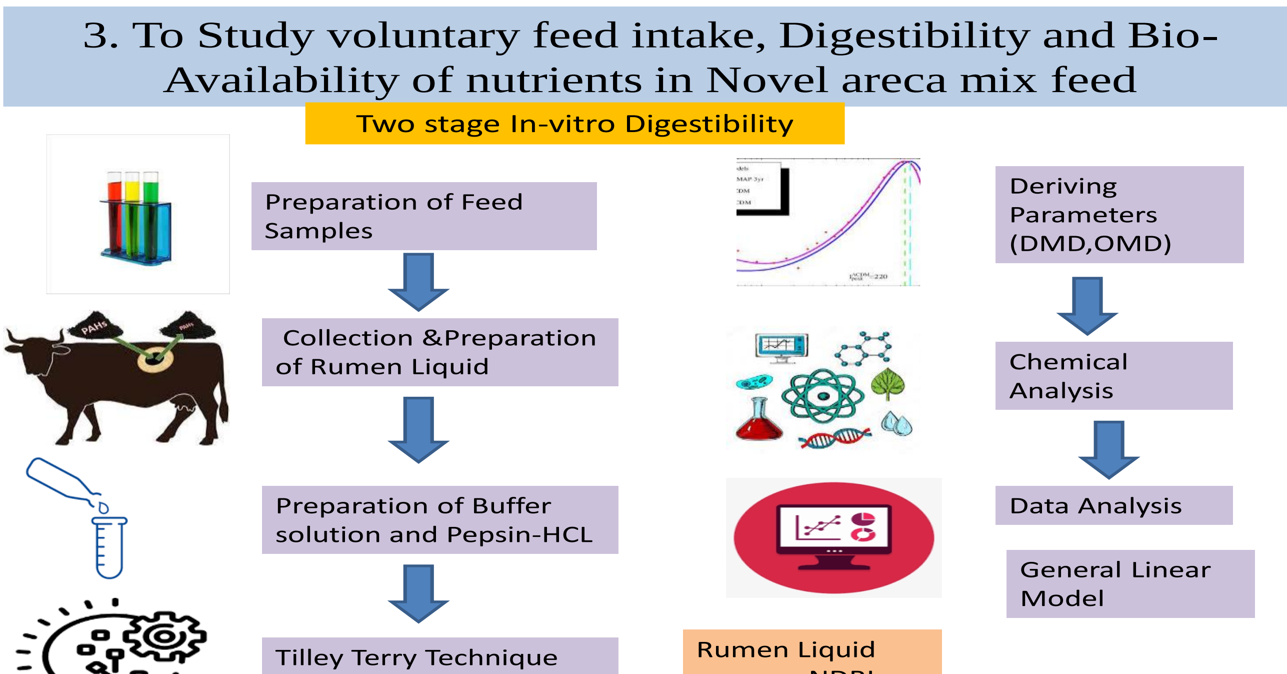
Treatment Groups	Formulation Ratio
T1	Market Compound feed (Zero % of Areca misplaced resource)
T2	Formulated Feed (10% of areca misplaced resource + 90% of (Maize, Gingerly de oiled cake, Cotton de oiled seed cake and barley)).
T3	Formulated Feed (20% of areca misplaced resource + 90% of (Maize, Gingelly de oiled cake, Cotton de oiled seed cake and barley))
T4	Formulated Feed (30% of areca misplaced resource + 90% of (Maize, Gingelly de oiled cake, Cotton de oiled seed cake and barley))



3. To test multiple myco-toxins and Bio-Availability of novel areca mix livestock feed.

Mycotoxins are toxic to animals and humans and their presence in feed is a global safety concern. Aflatoxins (AFs), ochratoxin A (OTA), and ZEA are considered to be of particular concern in feed. Mycotoxins have several effects on animal health, such as structural and functional damage to the liver, nephrotoxicity, hepatotoxicity, and immunotoxicity, in addition to poor weight gain in animals and decreased egg or milk production.

In vitro Digestion of Areca mix feed:

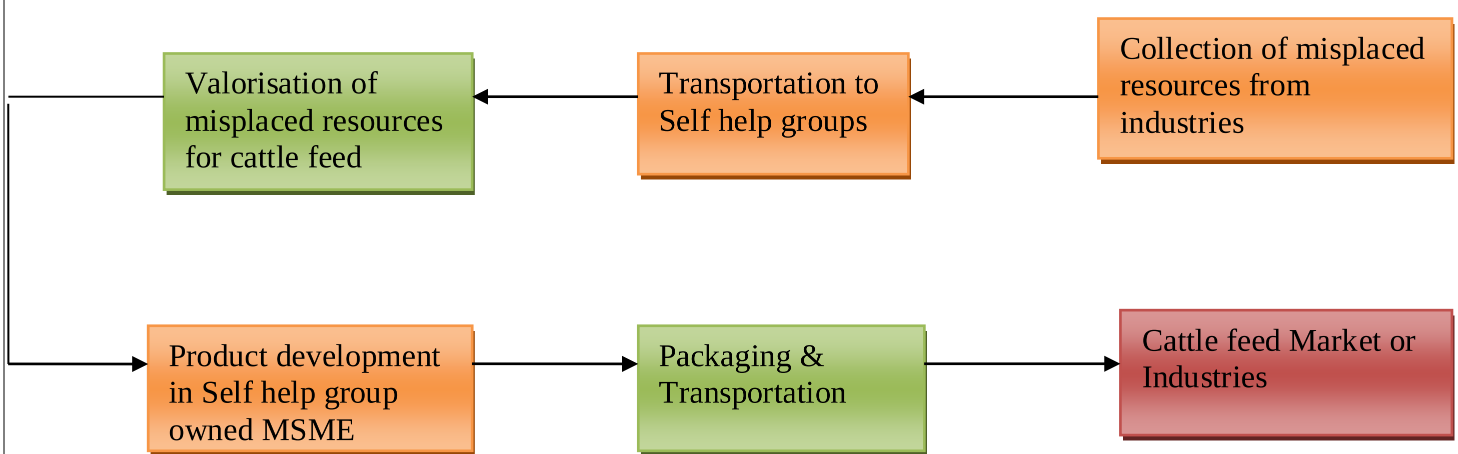


Charles et al.,(2016).

All materials are standard analytical grade. Sodium bicarbonate (0.5 M) should be filtered through a 0.22 μm filter under vacuum. It can be stored at 2–5 °C for approximately one month. The type of enzyme products, mostly provided by Sigma Aldrich (St Louis, Mo), is only a recommendation and similar products of comparable quality from other providers can be used. Enzyme activities are based on commonly used assays. Detailed protocols of the enzyme assays are outlined in the ESI.† α-Amylase (EC 3.2.1.1) activity is based on soluble potato starch: one unit liberates 1.0 mg of maltose from starch in 3 minutes at pH 6.9 at 20 °C. Porcine Pepsin (EC 3.4.23.1) activity is based on bovine blood haemoglobin as a substrate: one unit will produce a ΔA_{280} of 0.001 per minute at pH 2.0 and 37 °C, measured as TCA-soluble products. Porcine trypsin (EC 3.4.21.4) activity is based on *p*-toluene-sulfonyl-L-arginine methyl ester (TAME): one unit hydrolyses 1 µmol of TAME per minute at 25 °C, pH 8.1. Bovine chymotrypsin (EC 3.4.21.1) activity is based on *N*-benzoyl-L-tyrosine ethyl ester (BTEE): one unit hydrolyses 1.0 µmol of BTEE per minute at pH 7.8 at 25 °C. Porcine pancreatic lipase (EC 3.1.1.3) activity is based on tributyrin as a substrate: one unit liberates 1 µmol butyric acid per minute at 37 °C and at pH 8.0. Bile salt concentrations are measured using a commercial kit.

Objective 4: To frame the Business model for rural youths by using novel Areca mix feeds for livestock

- It will focus on generating rural employment through selected novel areca mix nutrient feed and designing supply value chain for areca sheath industry misplaced resources.
- Evaluation of shelf life analysis, Cost economics and market response study of formulated product.



Business Canvas Model:

<table>
<tr><th>Key Partners</th><th>Key Activities</th><th>Value propositions</th><th>Channels</th><th>Revenues Streams</th></tr>
<tr><td>1. Areca plate Manufactures
2. Areca nut cultivating farmers.
3. Social Innovation Fellows.
4.
5.</td><td>• Collection of Areca waste.
• Processing of the waste
• Shredding of wastes
• Nutrient profile testing
• Addition of protein rich materials with areca waste powder.
• Dry pelleting of the materials to produce nutrient pellets.</td><td rowspan="3"></td><td rowspan="3"></td><td rowspan="3"></td></tr>
<tr><th>Cost Structure</th><th>Key Resources</th></tr>
<tr><td>• Raw Materials cost
• Processing cost
• Transportation Cost
• Marketing Cost.</td><td></td></tr>
</table>

7. OVERALL DELIVERABLES/EXPECTED OUTCOMES

- Development of Low cost Novel Areca mix nutrient feed for livestock feeding.
- Development of Business canvas for rural youths with respect to novel cattle feed.
- Livestock feed production from areca industry misplaced resources would ensure lower processing steps and managing of areca misplaced resource in sustainable manner.
- Scientific publications, manuals, awareness and hands-on training programs

8. Work Plan:

S. No.	Activities	Timeframe (Semester)							
		I	II	III	IV	V	VI	VII	VIII
1.	Coursework completion								
2.	Field survey and Geo-mapping								
3.	Physio-chemical characterization of Areca misplaced resource resources								
4.	Formulation and Evaluation of Areca mix livestock feed								
5.	Bio-availability and toxicity testing of areca mix nutrient pellets								
6.	Frame Business Canvas or model								
7.	Synopsis and Thesis submission								

References:

1. Nanthini, A.R., Radhakrishnan, L., Gopi, H., Valli, C., 2018. Evaluating Nutritive Value of Arecanut Leaf Sheath as a Dry Fodder Source in Goats. The Indian Veterinary Journal 3.
2. Areca sheath as an alternate dry fodder for livestock | Feedipedia , URL https://www.feedipedia.org/content/areca-sheath-alternate-dry-fodder-livestock-0 .
3. Gowda, N.K.S., Anandan, S., Giridhar, K., Rao, S.B.N., Prasad, K.S., 2021. Alternate feed resources for safe usage in feeding practices. J Vet Anim Sci 52, 7–13. https://doi.org/10.51966/jvas.2021.52.1.7-13
4. Klasing, K.C., 2007. Nutrition and the immune system. *British poultry science*, *48*(5), pp.525-537.
5. Raidurg Ravi and Naveen M (2019). Surgical management of ruminal impaction due to feeding of arecanut sheath fibres in a heifer. Ruminant Science 8(1):133-134.
6. Naik, P. K., Dhuri, R. B., Swain, B. K., Karunakaran, M., Chakurkar, E. B. and Singh, N. P. (2013) “Analysis of existing dairy farming in Goa”, *The Indian Journal of Animal Sciences*. Delhi, India, 83(3).
7. Horticultural Statistics at a Glance 2018 Horticulture Statistics Division Department of Agriculture, Cooperation & Farmers' Welfare Ministry of Agriculture & Farmers' Welfare Government of India © Government of India PDES – 256 (E) Controller of Publication 500-2018 – (DSK-III).
8. Nair, K.P.P., 2010. 1 - Arecanut (Areca catechu L.), in: Nair, K.P.P. (Ed.), The Agronomy and Economy of Important Tree Crops of the Developing World. Elsevier, London, pp. 1–20.
9. Sujatha Sadasivuni, Ravi Bhat & Chowdappa Pallem (2015) Recycling potential of organic misplaced resources of arecanut and cocoa in India: a short review, Environmental Technology Reviews, 4:1, 91-102.
10. Reddy, P., Jakkula, R., Reddy, A.N., Kumar, D.S., Lakshmi, R.K. and Hyder, I., 2018. Assessment of Feed Resources Availability for Livestock in the Semi Arid Region of Andhra Pradesh, India. *Indian Journal of Animal Nutrition*, *35*(1), pp.59-65.

11. Sabithadevi, R., Sivasubramanian, K., Maheshwari, M. and Karthikeyan, S (2015), Assessing the quality characteristics of areca nut (areca catechu l.) leaf sheath misplaced resource to find its suitability for bio-composting.
12. Gurung, Nar (2020) "Nutritional Requirements of Different Classes of Meat Goats," *Professional Agricultural Workers Journal*: Vol. 6: No. 3, 10.
13. Cuesta, P. A., McDowel, L. R., Kunkle, W. E., Lawman, M. J., Bullock, F., Drew, A., Wilkinson, N. S., & Martin, F. G. (1996). Mineral Status in Beef Cattle, Live Weight Changes and Immune Response as Related to Selenium and Vitamin E Supplementation. Livestock Research for Rural Development, 8 (1).
14. NRC (2000). Nutrient Requirements of Beef Cattle. National Research Council, Seventh Revised Edition.
15. NRC (2012). Models for Estimating Nutrient Requirements of Pigs. National Academy of Sciences. Pp. 1 41.
16. Rayburn, E. D. (2013). Nutrient Requirements of Sheep. WVU Extension Service, Agriculture and Natural Resources, pp.1-2.
17. PRASANNAKUMARAN, K. and KIRUBAKARAN, V., Feasibility study of areca sheet misplaced resource as a biomass for downdraft gasifier.
18. Paul, S.S., Mandal, A.B., Chatterjee, P.N., Bhar, R. and Pathak, N.N., 2007. Determination of nutrient requirements for growth and maintenance of growing pigs under tropical condition. *Animal*, *1*(2), pp.269-282.
19. Hughes, E.H. and Ittner, N.R., 1942. The potassium requirement of growing pigs. *J. Agr. Res*, *64*, p.189.
20. Alcantara PF, Hanson LE, Smith JD. Sodium requirements, balance and tissue composition of growing pigs. J Anim Sci. 1980 Jun;50(6):1092-10.
21. Shashikumar, D.J. Shrinivasa, M. Anantachar and Veerangouda, M. 2017. Conceptual Design of Arecanut Sheath Shredder. Int.J.Curr.Microbiol.App.Sci. 6(10): 1920-1929.
22. Letha Devi, G., Malik, P., Mech, A., Dhali, A. and Khandekar, P., 2012. ICAR-NIANP News letter Jan-Jun 2012.