Chapter 4
Review of Science and Technology Interventions Developed by Rural Technology Action Group, IIT Madras

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1 Introduction

India lives in its villages with 69% of its population in rural areas [1]. It has been noted that in the post-independence era, the focus of Science and Technology (S&T) interventions by the Government of India has leaned towards the needs of the industry and urban settlements, thus neglecting the vast rural population [2]. This is titled as preference of 'macro-S&T' over 'micro-S&T' [3]. In order to obtain optimum benefits from infrastructural development efforts of the Government such as roads, water supply, agricultural inputs, health and educational facilities, etc., it is essential to identify any gaps in the system of development and dissemination of rural technologies [4]. Presently, technology dissemination is found to be slow and uneven in rural areas, one of the main reasons for which is the absence of proper institutional linkages to create a demand for technologies [5]. In many cases of Science & Technology developments, it has been found that the technologies remain confined to R&D institutions [6].

In order to bridge these gaps, Rural Technology Action Groups (RuTAGs) were established in several IITs across the country by the Office of the Principal Scientific Adviser, Government of India. RuTAG was established in 2004 in Indian Institute of Technology, Madras (IITM) in order to act as an enabling link between technical institutions and rural people/organizations working for rural areas of the five southern states. Most of the projects undertaken by RuTAG, IITM are in the areas of livelihood creation, drudgery reduction, increase in efficiency/productivity of processes, local resource management and knowledge generation for further applications in rural context.

This review covers six technologies developed by RuTAG, IITM which have resulted in either livelihood generation or improvement of productivity by means of

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drudgery reduction. Each technology is from a unique technical sector, highlighting the diversity of S&T interventions developed by RuTAG, IITM.

2 Science & Technology Interventions by RuTAG, IITM

Over the past decade, RuTAG, IITM has been involved in over 55 projects spread across sectors of livelihoods, assistive technology, health and sanitation, energy and textiles, as highlighted in Fig. 1. This review focuses of six of the most promising interventions completed by RuTAG, IITM, as depicted in Fig. 2. RuTAG, IITM also organizes workshops in various places inviting local NGOs and technical institutions to generate problem statements and invite proposals from the institutions to take up R&D projects. This bringing together of localized organizations helps to foster a sense of ownership towards the problems and their solutions.

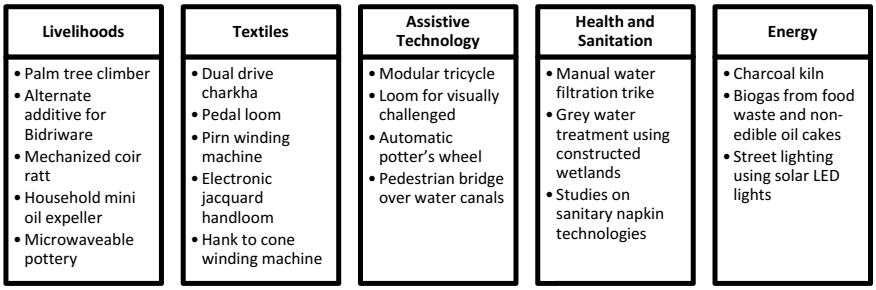


Fig. 1 Projects undertaken across sectors by RuTAG, IIT Madras

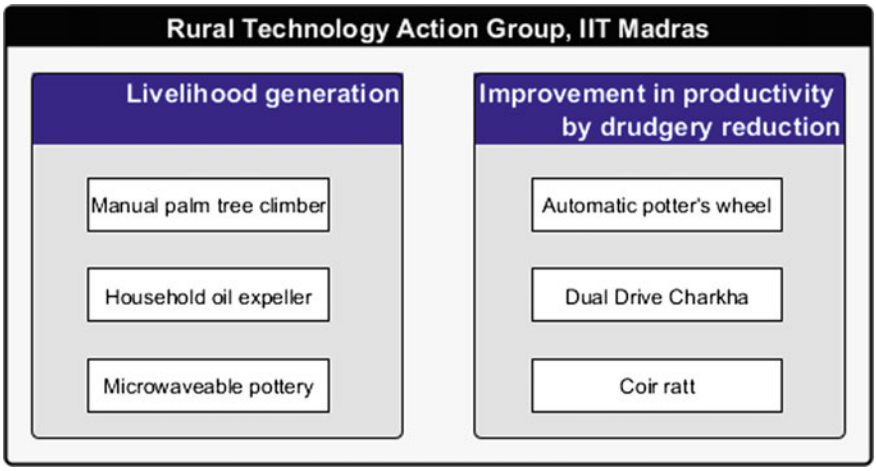


Fig. 2 Reviewed S&T interventions of RuTAG, IIT Madras

Table 1 Preliminary body composition of microwave-compatible products utilizing common red burning clays from West Bengal

Constituents	Weight (%)
Bikaner ball/plastic clay	20
Ranchi plastic clay	15
Red clay grog	20
Raw red clay	25
Sand	04
Feldspar	15
Talc/steatite	01

A recent unique initiative of RuTAG, IITM has been a reach-out programme for over 25 polytechnic colleges around Tamil Nadu and Kerala to encourage faculty members and students in quicker development of prototypes for specific problems. RuTAG, IITM has also conducted a technical proposal-writing workshop for faculty members from engineering colleges in order to increase presence of RuTAG and welcome technical proposals from them.

2.1 Interventions in Livelihood Generation

RuTAG, IITM has been a linkage between many governmental agencies, non-governmental organizations and technical institutions for providing timely assistance in reviving diminishing professions by creating newer opportunities as in the case of the microwaveable pottery and increasing access to the profession by easing the process in case of manual palm tree climber. RuTAG has also helped to tap additional income generation opportunities with project like the household oil expeller. The following projects have been explained in detail in the following sections.

Microwaveable pottery: In order to introduce manufacture of value-added pottery products in potter clusters in Nagercoil and Kanyakumari districts, Tamil Nadu, a process for producing microwave-compatible wares utilizing common red burning clays was developed [7]. Various raw materials were characterized followed by the formulation, making of casting slip, fabrication of wares, firing in electric kiln and testing for suitability in microwave oven. In order to ensure reuse of the bowls, a compatible glaze coating was developed. The compositions of the body and glaze are listed in Tables 1 and 2 respectively. The cost of production per bowl of 1 L capacity, as shown in Fig. 3, was estimated to be Rs. 28.30 in 2014.

The results in Table 3 clearly indicate that the body matured at 1120 °C almost attained vitrification with water absorption value 0.58% and porosity 1.36%. The shrinkage value is rather low and this would be advantageously utilized in controlling the warpage of the wares. The lower fired shrinkage value in association with lower coefficient of thermal expansion would make the body robust and thermal shock resistant. Similarly bulk density is also on the lower side indicating presence of

Table 2 Preliminary matching glaze composition of microwave-compatible product utilizing common red burning clays

Ingredients	Weight (%)
Frit 1103	81
Rajmahal white clay (Calcined)	3
Rajmahal white clay (raw)	7
Quartz (calcined)	5
Talc	2
Zinc oxide	2

Fig. 3 Glazed bowl of 1 L capacity after firing

amorphous phase in higher proportion than that of crystalline phases. As shown in Fig. 4, the XRD analysis of the matured body indicates that major phase is amorphous in nature which is desirable to make the body microwave compatible. Quartz and mullite are the observed crystalline phases.

With the process development and validation completed, a common facility centre is to be established with the required equipment in order to open up newer arenas for the potter clusters by way of manufacture and marketing of microwaveable pottery product line.

Household oil expeller: The oil expeller consists of a screw in a sealed chamber having inlet and outlet for seeds and oil cake respectively. A study on commercially available oil expellers was done to find that the existing machines used hot press

Table 3 Typical cast and fired properties of bowls of 125 mm diameter

Property	Unit	Value
Casting time	min	40
Hardening	min	120
Thickness of cast	mm	10
Fired shrinkage	%	4.2
Water absorption	%	0.58
Apparent porosity	%	1.36
Bulk density	g/cc	2.33
Coefficient of thermal expansion	$\times 10^{-6}$	6.182

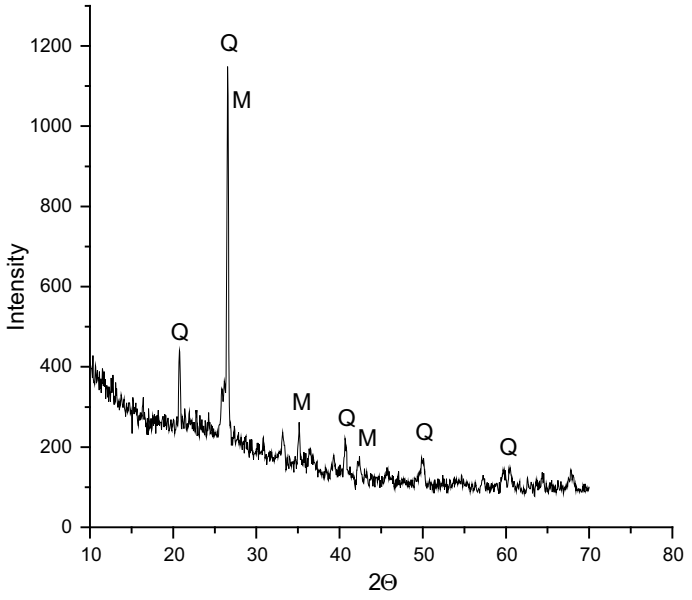


Fig. 4 XRD analysis of the fired body

method, resulting in decrease of nutritive content of both oil and oil cake products [8, 9]. Other drawbacks observed were requirement of multiple crushing to obtain good yield, opening up of device in case of seeds getting stuck during crushing and slow feeding time of larger seeds.

In order to overcome these drawbacks, design modifications involving tapering of the screw and trial of mechanisms to increase compression rates were carried out to enable efficient oil extraction using the cold press method [10]. The continuous mechanical pressing using a screw press has been recommended for small farmers due to its small scale, lower cost and obtaining good quality oil cake product for animal feed and fertilizer applications [11]. The taper expeller screw has a variably increasing pitch value so that the seeds will experience a complete crush without

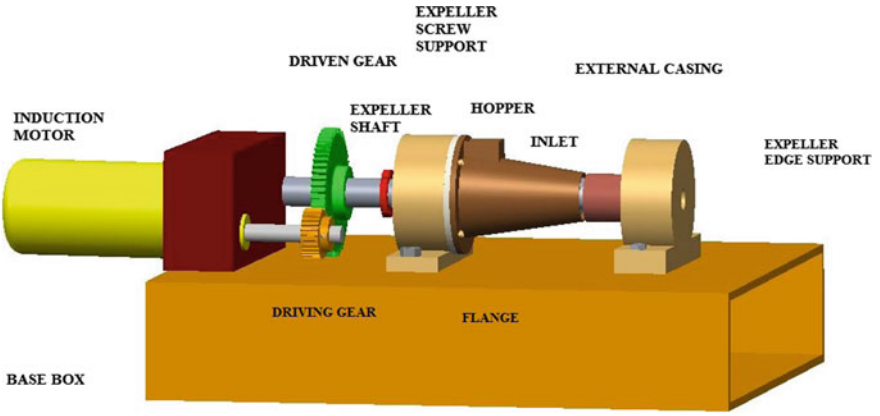


Fig. 5 3D model of general view of oil expeller

Table 4 Trials for 500 gm of seeds with 1/3 reduction in gear mating mechanism

Sr. no.	Parameter	Unit	Groundnut seeds	Sesame seeds
1	Feeding time	min	11	5
2	Oil flow time	s	22.3	23.2
3	Temperature of oil	°C	34	35
4	Oil yield	%	30.6	28.8
5	Efficiency of machine	%	55.6	55.2

using a pre-heater element, thus getting good yield of cold pressed oil. Open belt and pulley drive mechanism is used in the expeller machine to increase the compression rate. An induction motor of 0.5 hp is used to power the machine and a DC motor of 1 hp with belt and pulley mechanism is used for effective compression. A hand operated lever switch is connected to the expeller machine, so that the machine can run both in clockwise and anti-clockwise direction. The 3D model is shown in Fig. 5, along with trial results of the machine in Table 4, which highlights a good oil yield of ~30% during trials. The cost of fabricating a single unit of machine was Rs. 27,000 in 2016.

Manual palm tree climber: There are many existing manual, motorized and robotic climbers aiming to ease the operation of coconut tree climbing and provide a stable source of income without the dangers involved in it. Some of these are heavy and difficult to use and also do not provide safety of operation. Palm (also known as palmyra) trees are different from the coconut trees due to varying trunk diameter, texture and slant even in a single tree. An existing manual coconut tree climbing device of The Kerala Agro Industries Corporation Ltd was modified, as shown in Fig. 6, to cater to climbing of palm trees [12]. A comparison of the two climbers is listed in Table 5. Upon demonstrating to the current generation of palm tree tappers, the product developed interest for further trials and feedback.

Fig. 6 Manual palm tree climber developed by RuTAG

Table 5 Comparison of coconut and palm tree climbers

Parameter	Existing KAIC climber	Modified RuTAG climber
Weight	10 kg	8.5 kg
Specifications of steel used	10 mm steel rods	Steel tubes with OD 12.7 mm
Measure for safety	None	Safety harness with hook attachments
Cost	Rs. 2600 (2014)	Rs. 5,500 (2016)
Ease of operation	Easy to use, but lack of safety attachment may deter untrained people from using	Easy to use incorporating a safety harness to prevent a fall in case of loss of grip

Table 6 Technical specifications of automatic potter's wheel

Specification	Value
Type of motor	Capacitor start induction motor
Capacity of motor (hp)	0.5
Speeds available (rpm)	1440; 960; 720
Ratio of speed from motor to load	14:1

2.2 Interventions in Productivity Improvement by Drudgery Reduction

Many of our traditional processes largely involve long hours of manual labour. While retaining employment of people is to be kept in mind, a few more devices or modifications of existing devices can go a long way in reducing drudgery of people, thus improving their productivity and thereby their income. RuTAG, IITM has aptly illustrated this, through the case studies of the automatic potter's wheel, coir ratt and the dual drive charkha in the sectors of traditional occupations of pottery, coir rope-making and khadi industry respectively. The following sections describe the interventions in detail.

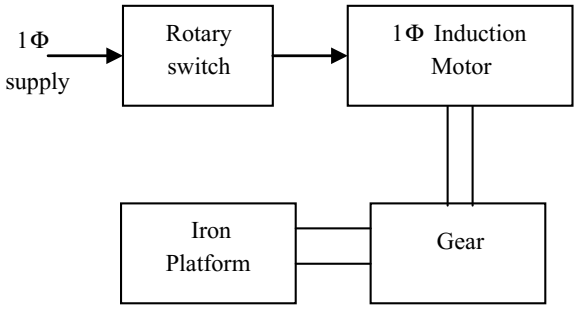
Automatic potter's wheel: Moulding of pots has usually been done on a potter's wheel with the potter manually adjusting the speed as required. This process is time-consuming with a lot of drudgery involved. An alternate automatic potter's wheel was developed with electrical arrangements to vary speeds as desired [13], the specifications of which are listed in Table 6. The potter's wheel, as shown in Fig. 7, cost Rs. 13,000 to fabricate in 2010 and has been installed in two potter clusters each in Tiruvallur and Nagercoil districts in Tamil Nadu.

As illustrated in Fig. 8, three windings are connected to the single phase AC power supply using a rotary switch. By changing the position of the switch, the supply given to the windings are changed, thereby changing the fields and achieving different speeds. The gear is connected to the iron platform, on which the clay is placed. Through pulley and belt drive mechanism, energy is transferred to the shaft of the potter's wheel.

Coir ratt: Manufacture of coir fibre, yarn and coir-based products are important traditional industries of Kerala. The industry employs around 7 lakh workers from mostly rural economically backward sections, 70% of which are women [14]. The existing processes in the coir rope-making industry are out-dated and labour-intensive, resulting in inconsistency in quality of the rope. Most women spinners often walk long distances to the place of work to manually spin the yarn into ropes. A machine to make the popular Vycome type of rope was designed to bring in mechanization in the coir industry and encourage independent home industries. This rope is soft or medium twisted and is typically wheel or hand spun 2 ply yarn made of coir fibre of natural brown to grey colour.

Fig. 7 Automatic potter's wheel developed by RuTAG

Fig. 8 Block diagram of automatic potter's wheel



Before finalizing the design parameters of the machine, a test bed machine was made to experiment with various combinations of speeds and centre distances/angles between the rollers to obtain best quality of rope [15]. The prototype was constructed based on results from the test bed and produces Vycome rope as per IS 14596:1998 with three different speed combinations as per convenience and skill of the spinner [16], as highlighted in Table 7.

Running on a 0.25 hp single phase AC motor, the machine weighs 70 kg, stands 65 cm high and has length × width of 57 × 51 cm. The machine consists of (a) Input feed roller-cum-twister; (b) Static twister; (c) Output Twister-cum-pulling mechanism and (d) Drum, as shown in Fig. 9. The two strands of rope are fed through the

Table 7 Rope productivity and quality results for three modes of functioning

Speed	Speed of input feed rollers	Speed of Twist-ing/pulling mechanism	Productivity	Twist per metre	Average rope diameter
	rpm	rpm	m/min	/min	mm
Low	540	140	2.66	45	4.5
Medium	640	140	2.71	55	4.5
High	640	180	3.55	50	4.5

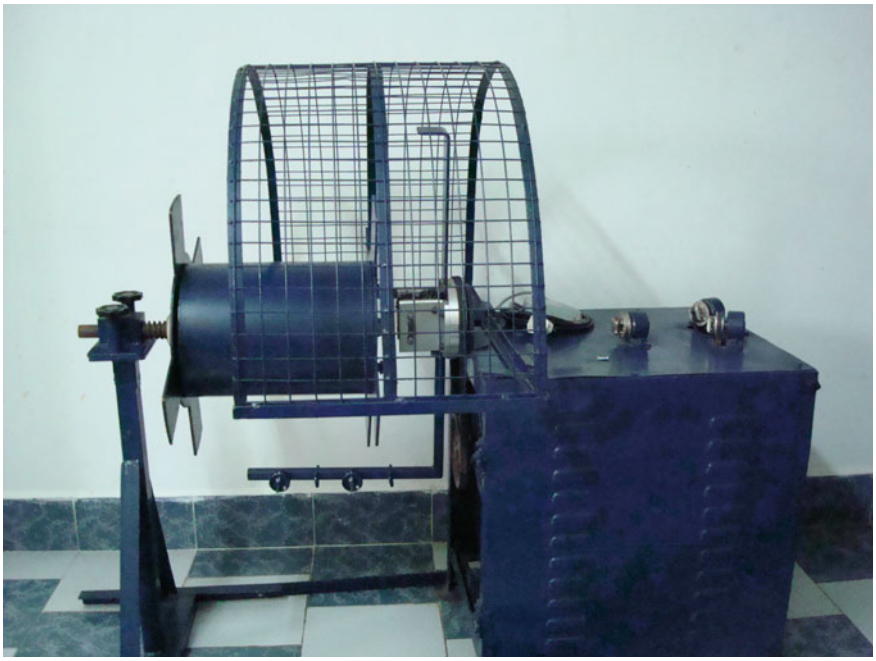


Fig. 9 Coir ratt developed by RuTAG

two input feed rollers, which simultaneously roll and twist the rope. They are driven by a belt from the motor below. The combined yarn then goes through a static twister which prevents untwisting of the yarn. The knurled rollers on the twisting-pulling mechanism give the final twist and simultaneously pull the rope out of the machine to wind onto the rotating drum, which can accommodate up to 500 m of rope. The quality and consistency of the rope was testified by coir workers from Indian Coir Spinners (Women) Association, Alappuzha, Kerala. The cost of fabricating the single piece of coir ratt in 2006 was Rs. 13,000.

Dual Drive Charkha: The charkha is a manually operated machine used to spin yarn from natural fibres. In order to reduce fatigue in the workers and improve the

Fig. 10 Dual Drive charkha with ergonomic stool

productivity, the pedal-operated charkha designed by RuTAG, IIT Kharagpur was procured and modified. A unique Switch-at-will dual drive charkha was designed with readily available spare parts of a bicycle [17], as shown in Fig. 10.

In order to smooth the rotary motion of the charkha, the V-shaped pedal of the pedal charkha was replaced by a bicycle pedal with chain drive. By using the rear sprocket freewheel of a bicycle, when one drive is operated, the other drive parts remain stationary. Hence, the hand drive could be fixed on the main shaft permanently, thus introducing the dual drive functionality in the charkha. For ergonomic comfort, the location of wrap reel was changed from side to top of the frame, thus improving reach of the operator. A special ergonomic stool was designed to adjust height and ensure comfortable pedalling with a better reach for the operator.

Switching drives in this charkha helps manage fatigue of worker without causing any machine down time. This increase in working time leads to increase in output of machine. Upon feedback from operators after initial trials, the Cycle Pedal to Crank Shaft 'Drive Ratio' was changed from the initial value of 2.4–2.2 at first stage and then to 2.0 in second stage. This resulted in increase in production from 20 hank to 22 hank and then to 24 hank respectively for count Nm 33. A potential rise in production

of 25–50% has been estimated during the trial run of 6 months at Nedumbunnam Khadi Production Centre, Kottayam, Kerala.

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