Proposal of Sustainable Stone Grinder (石臼) For Realization of Super Smart Villages

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Abstract: Stone grinder, an essential food processing tool for people in the Himalayan villages has been used for centuries. It is a very important tool for the local communities to continue their livelihoods sustainably. It will be even more important especially in post COVID-19 era to practice sustainable organic livings and social distancing. However, due to its heavy weight, children and senior people are not able to utilize this tool efficiently and thus losing its popularity now a days among them. In this paper, we devised a "Sustainable & Trustable" food processing technology and platform that can contribute to preserve the traditional knowledge and address those limitations so that it will be a foundation towards achieving "Sustainable Society". The newly designed food processing prototype (*Aamako Jato*, literally means mother's stone grinder) was evaluated and revealed that it reduced the total operational time of the users significantly (i.e. 80% reduction of operational time). Furthermore, this system does not require manual operation, and thus, can be operable from anywhere by anyone such as children, women, and senior people.

Keywords: Sustainable Computing, *Aamako Jato*, Traditional Knowledge, IoT, Super Smart Village

1. Introduction

Sustainability covers a broader scope. However, in this paper we have limited our study within traditional equipment (i.e., stone grinder) and its enhancement through the perspective of sustainable computing. In our previous study [1] we investigated the mechanism of stone grinder in traditional settings and demonstrated how an IoT and AI enabled stone grinder could be a viable solution. In this paper, we further enhanced this research with sustainable computing perspective and proposed a novel food processing system which could be a viable solution to realize smart village in the context of post corona era. In a broader sense sustainable life based on traditional knowledge has contributed significantly to survive and sustain the livings of communities in Himalayan regions. For example, there are several traditional tools and technologies which have been developed a long time ago and ever since they are in usage in order to support the livings of Himalayan people. These tools were required to facilitate the livings of local people and were aimed to increase the productivity of that era. These tools are made up of stone, leather, mud, and irons. Some of the tools often used in Himalaya areas are *Khukuri* (Metalic Knife), *Aasi* (Metalic Sickle), *Bauso* (Metalic Spade), *Nanglo* (Bamboo Sieve), *Halo* (Wooden Plough), *Dhiki* (Wooden Thresher), *Jato* (Stone Grinder). Most of these tools are agricultural related which were often used in order to sustain their livelihoods and to engage in wage activities.

Among these tools, our study has focused on Jato (We called it *Aamako Jato*, literally means a stone mill of mother, in our study), a stone mill generally uses in almost every households of Himalayan people. Still today, it has been used to grind rice, wheat and other agricultural food grains in some of the households in Himalayan region of Nepal, Sikkim, Bhutan and India. However, this tool is very heavy so that women and children feel difficulties to operate this device. It is made up with two round shaped stones, bed and top stones. The top stone is pierced with two holes, one of which is used to feed the grains and the other hole is used to keep the metallic nail or spindle in order to retain the stone intact while rotating. Though the significance of these tools has a great impact for the sustainability of the locals, the knowledge behind it has often been ignored or neglected and thus is in the verge of extinction. In this paper, we discuss a detail method of enhancing this traditional tool, which utilizes CPM (Cyber Physical Modeling), Physical construction or implementation, IoT enabling process and expected results.

2. Research Objectives

Despite its valuable contribution in food processing, this tool is very heavy for women, children, and senior people. Figure 1

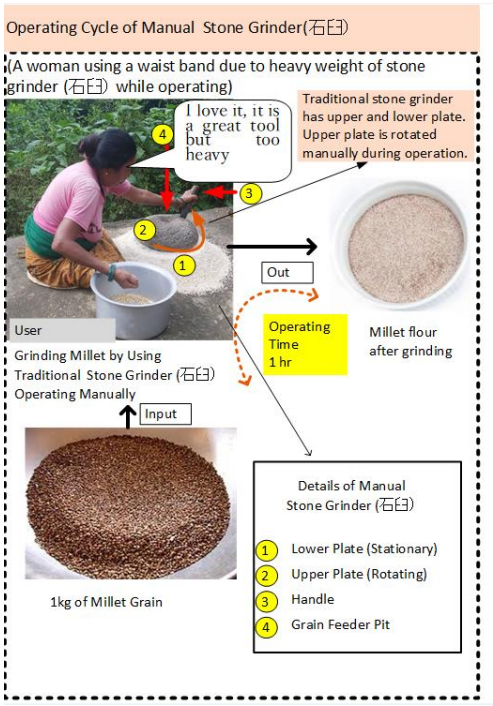

Figure 1: Operating Cycle of Stone Grinder

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depicts the typical usage scenario of traditional stone grinder. Here, a woman is using stone grinder manually to grind millet. Due to its heavy weight, she needs a waist band in order to support her backbone while operating this device. This kind of stone grinder is used in the villages of Himalayan areas of Nepal, Bhutan, India, and Pakistan for the past many centuries. However, due to its heavy weight, children, women and senior people cannot handle this tool properly. Thus, we aimed to introduce more user-friendly food processing system while preserving its unique grinding mechanism by using IoT and AI technologies. The final goal of our research is to contribute to the realization of super smart village which is very challenging and requires series of steps. Thus, we have divided our research goals into following categories:

2.1 First Objective

The first objective of this research is to propose a sustainable stone grinder which is user friendly for the entire generation. The immediate effect of this research will make the device more user friendly and operable from anywhere by anyone at any time.

2.2 Second Objective

The second objective of this research is to revive the traditional tools and knowledge with modern mind and cutting-edge technologies, thereby creating new job opportunities and improving quality of life in rural villages. The most rural villages are facing population declining due to the outflow of youth to the urban areas and foreign countries.

2.3 Third Objective

The third and final objective of this research are two folds. The first one is documenting the development method of stone grinder with modern and new technological settings. The second one is to realize super smart village that improves the livelihoods of rural communities by enhancing traditional tools and knowledge with modern mind and technologies. To achieve this goal, we have conducted a number of researches[1]–[5] previously, and the lessons learned from those projects are well incorporated in this work too. This is our the most important goal of the research which can be achieved after achieving our primary and secondary objectives. We strongly believe that realization of sustainable user-friendly technology is only possible if the modern technology is developed and promoted based on local knowledge and available resources.

3. Literature Review

There are very limited studies that utilized the traditional knowledge to meet the growing need of the modern society, especially in the Himalayan region. However, few studies such as [6], [7] studied the indigenous knowledge and practices that are carried out in different parts of Nepal. The study of traditional knowledge has been spotted in few papers. Sharma etal. [8] has documented a review article regarding water resource management, soil fertility management, indigenous knowledge on biodiversity and forest management, indigenous knowledge on pest management, bio-fencing, agricultural tools on the basis of traditional knowledge and beliefs from Kavre, Baglung and Kaski district of Nepal. A report has been published [9] that identifies a number of indigenous, traditional and local knowledge and practices and analyzes their applications for climate change adaptation and resilience-building at the local level. In 2014, a similar study that comprises of six case studies was carried out by the Government of Nepal, Ministry of Science, Technology and Environment [5]. These case studies were related with indigenous practices that include local water management practices; forest and pasture management; rural transport infrastructure; settlements and housing; and traditional social institutions that link between climatic risks and settlements in Nepal and how indigenous responses can minimize risks and enhance resilience. However, none of these studies had examined the application of IoT or any ICT related technologies with traditional knowledge or practices. Besides Nepal, Sharma et al. [1] conducted there were some comprehensive study on the traditional technologies and tools in Indian communities. Similarly, Lal and Verma [10] studied soil and water management systems that are suitable for different agro climatic conditions of Himanchal Pradesh in India.

Most of these studies were documented the status of indigenous knowledge or practices. There is no scientific and systematic study attempted to link traditional knowledge with modern technology in the context. Thus, we realized that there is a need to evaluate current status of traditional equipment of Himalayan region of Nepal and proposed a method by which these tools can be enhanced with latest technologies for sustainable rural development.

4. Methodology

4.1 Modeling

In this research, the stone grinder was initially modeled by using 3D graphics tool. The completed 3D models with three different stages of modeling is depicted in Figure 2. We designed a 3D modeler by using box modeling method. Box modeling method is the most efficient method to design such kind of stone grinder in which the primitive such as a cube, a sphere, or a cylinder can be utilized to form the final product. We simulated and evaluated its cost and productivity that suits our intended output. We devised a prototype of stone grinder for this refined model and recommended list of dimensions to construct the real object of stone grinder (Table 1). Finally, a stone grinder was crafted using this framework.

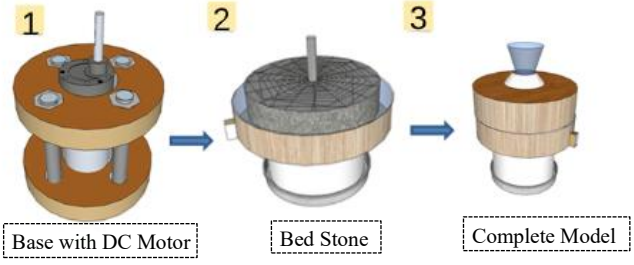

Figure 2: 3D modelling steps of Stone Grinder

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Table 1: Dimension and Description of Stone Grinder

S.No	Name of Material /Parts	Dimension and Description	Purpose
1	Career	Radius: Have Supported with 4 wheel tyre	To move and handle the Aamko Janto
2	Base	Radius: 7.5 cm Radius of whole: 5cm Knot and Bolts: 4 pieces, length: 15cm, inside height 9.5 cm	To fix and stand motor statically upward
3	DC Geared Motor	Specification: 24 V, 5Amp	To rotate the stone grinder
4	Top Stone and Bed Stone	• Radius: 15cm • Thickness: 6 cm • Weight: 11kg	These are the main components which are used to grind the grains
5	Lid	• Upper Lid and Lower Lid • Radius: 18 cm • Depth: 7.5 cm	To cover the top and bed stones,
6	Platter with fixer		To maintain leveling of the contact surface and to balance the feeder funnel
7	Spindle (Mani)	Length: 19cm Diameter: 22mm Inside Hole: 12mm	To rotate top stone
8	Funnel and Other materials	Depend upon the stone grinder	To feed the grains
9	Power Supply	AC to DC power supply	To provide required voltage and current for device
10	Arduino	Arduino with Wi-Fi sheild	To control the device through embedded program

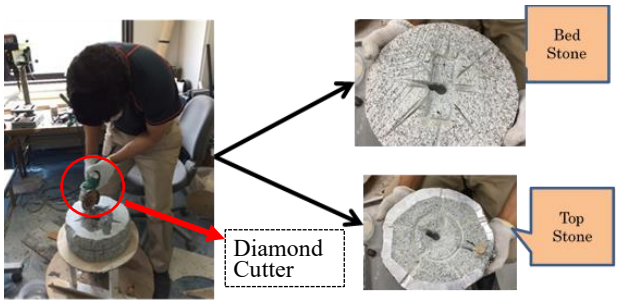

Figure 3: Crafted Stone Grinder by Principal Investigator

4.2 Sustainable Carving and Crafting

The real stone design and construction work was done which is shown in figure 3. Here, both the bed and the top stones were originally crafted from scratch by using a diamond cutter. This was carried out to investigate the total time taken during crafting process for traditional stone grinder. In traditional settings, stones were cut, and crafted by using more conventional tools such as hammer, metal pick (local name: *Tautuke)*, point and punch (local name: *chhino*). These tools were used to carve the stone and to modify the shapes as per the requirement. In present days, this process can be enhanced by using more relatively sophisticated tools such as diamond cutter. However, in order to practice the sustainable development, it is needed that resources, tools and knowledge applied during the development process must be both inclusive and environmentally sound. Therefore, we utilize the locally available stones and relatively less sophisticated tools while crafting the stone grinder. In contrast, mass production with external resources are not sustainable development practices and thus were avoided in our development process.

Figure 4: Locally set up stone grinder in Nepal

4.3 Deployment

The lab grown stone grinders were used in several food festivals program organized in Wakkanai, Japan. Here, the stone grinder was used to grind the rice and produce rice flour. Furthermore, a locally developed stone grinder was deployed in a remote village of Himalayan region of Nepal (i.e. Dhital, Kaski, Nepal). Figure 4 indicates the locally established stone grinder which was constructed by using locally available resources. These resources include stones and metal which were managed locally. To rotate the stone, DC (Direct Current) motor was used. Energy resource for this device can be provided by using solar panel which can be managed locally without much problem. We got a very positive feedback from the local user who used to be a regular user of traditional stone grinder. This stone grinder which was locally crafted is automated by using DC motor. This reduced the operational time of the user significantly and it is usable by women and children also because it does not require manual operation.

5. Expected Results and Evaluation

We estimated the time efficiency for this food processing system. We modeled a non-linear function, where *f(x)* is an operating time in hour as a function of age of operator (a) for a constant quantity (q) of grain.

$$f(x) = ax^b \quad \text{----------(1)}$$

We assumed that a person with 30 or less than 30 years of age can process 1 kg of millet in one hour; whereas after 30 years of age, productivity will attenuate as the operator gets older. This phenomenon resulted our function to be a non-linear. We capped the age of operator to 70 years. Our expected result is plotted in graph (Figure 2).

We also simulated this operation and calculated time saving for an operator. We found that a user can reduce his operational

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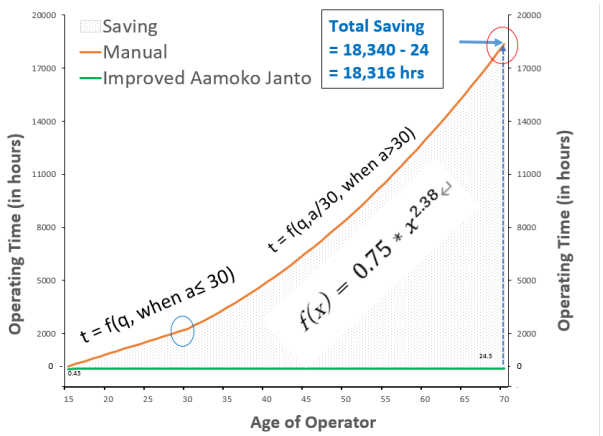

Figure 5: Time Efficiency Estimation (Here, orange color represents a non-linear time consumption stone grinder while using manually. Green color line represents the static operating time for the same amount of grain while using the proposed model of stone grinder)

time by more than 80% (Figure 5) in each attempt of operation. This result was calculated based on our lab grown stone grinder. However, the locally designed stone grinder has not produced result in a such level. Nonetheless, local user can start the grinder and let it run while doing other tasks which was not possible while using the traditional stone grinder. In our future work, the fully automated stone grinder which is remotely operable will be developed and deployed locally.

Figure 6 depicted the future scenario of our stone grinder. This figure compares the conventional usage scenario and the future usage scenario (please refer figure 6 for details). Once the food processing system is fully developed, a user can operate this device from anywhere at any time by children, women and senior people. In our future work, we expected to set up the stone grinder which is IoT and AI enabled. The fully developed protype is expected to produce the following results.

5.1 Strengthen family bonding

Our fully developed stone grinder (Principal investigator named it as *"Aamako Jato"* means mother's stone grinder*)* is expected to increase family bonding. These days, most of the rural areas in Himalaya and many local cities around the world are facing population declining. In the case of Nepal, many youths have been migrated to cities and aboard either to study aboard or for seeking employment. This situation made local villages popularly known as "youth less" and "toothless" society. From sociological point of view, lots of families are divided and living their lives separately. *Aamako Jato* is expected to contribute strengthening the family bonding. This would be possible as *Aamako Jato* is remotely operable from anywhere of the world at any time. For example, the children living aboard can start *Aamako Jato* set up in Nepal and can help their parents household's work. This feature will be utilized to take care of their family. Furthermore, 3D space of their family will be shared by using holoporation technology.

5.2 Sustainable Super Smart Village

Many researchers focused on realization of smart cities; however, limited research were conducted to address the contemporary issues and challenges in rural villages. However, experiences learned from our previous experience on smart cities

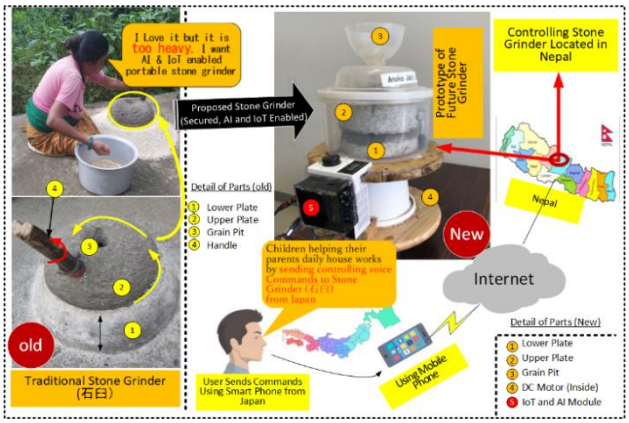

Figure 6: Future usage scenario of stone grinder

initiative could provide foundation for the rural setting despite they have vast socio-economic differences. We recognized those differences and challenges in order to develop smart village in a rural areas. Specifically, the challenges including the definition of smart villages is well described in EU Action for Smart Villages'[11], [12]. It stated that these villages which build on their existing strengths and assets as well as new opportunities to development or livelihood improvement added value, and where traditional and new networks are enhanced by means of digital communications technologies, innovations and better use of knowledge for the benefit of inhabitants. In the context of Himalayan villages, we redefine smart village concept that it is a solution for social innovation that addresses the challenges of rural areas where local resources play a central role for sustainable community development.

To this context, *Aamako Jato* could play a key role to enhance the livelihoods of local people by reducing their operational time while grinding their food ingredients. We aimed to promote the initiative of a super smart village where we can resolve various social challenges by incorporating the innovations of IoT, big data, artificial intelligence and by sharing new values and economy among the local people. By doing so, the village communities will be united to address their common needs and challenges in which new values and services are created continuously that will enhance their lives more conformable and sustainable. Research on *Aamako Jato* is carried out as a tool of smart food processing technology. By using this device in their daily food processing system, village people will enjoy their spare time with their family and for other productive work to sustain and improve their livelihoods. The framework developed in this research can be easily replicated elsewhere for the development of smart village.

6. Conclusions and Next Steps

Traditional food processing tools remain little studied by researchers, engineers, or scholars. We investigated traditional food processing system to enhance organic and healthy livings the importance of which was revealed more significantly after COVID-19 pandemic. In this study, we introduced a novel method by which a traditional food processing tool can be enhanced by using cutting-edge technology (i.e. IoT and AI), and make it a sustainable food processing system, especially for rural

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communities. Particularly, we developed an enhanced IoT enabled stone grinder and named it *Aamko Jato*, an aged old traditional agricultural tool, though still in used, but is in the verge of extinction. This undesirable phenomenon can be addressed by applying proper designs and re-tooling method as discussed in this paper. We expected that a remotely operable *Aamako Jato* can contribute to strengthen the family bonding and also to realize the smart village through improvement of quality of life. The realization of smart village is possible and will be sustainable only if the development processes are executed based on traditional knowledge and carefully enhanced by latest technologies. Furthermore, to promote sustainable development, these solutions should be developed based on local resources and accepted by the local communities. We devised a conceptual framework and development process by which traditional tools can be enhanced without much losing their underlying design, knowledge and features while adding new intelligent features. In our future work, we will further investigate the actual impact of *"Aamako Jato"* to the livelihoods of local people and its contribution to local economy, quality of life and sustainable community development for the realization of super smart village.

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