

# Project Summary

## Georgian Small-Scale Farmer Nutcracker

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### Background and Project Goal

Georgia is a country located in the South Caucasus region of the Middle East. The population of the country is 3.4 million and 60% of them are involved in agricultural activities. One of the high value agricultural products produced in the country are nuts. 80% of hazelnuts produced in the country are exported to the world market. Walnuts produced in Georgia are consumed in the country as they are widely used to prepare national dishes. One of the main activities for the farmers involved in nut production and collection is breaking the nuts to get a high price for the produce. Mostly rural women work breaking the nuts and they spend several months, from September till December, doing so. It is very hard work for the women and they work from early morning till night.

Our specific community for this project is Tusheti Protected Areas Friends Association in Georgia, Kakheti Region, Akhmeta municipality and the client is Kakha Bakhtadze. For this project our goal was to develop a nut-breaking tool at a price point small farmers can afford (below 1250 USD) that must be able to efficiently break different sizes and species of nuts. The farmers currently crack nuts by hand using a simple hand cracker (see appendix 1), which makes the process slow. The client is looking for a new technology that will be more efficient while maintaining cultural structure. Ideally walnuts would be cracked into halves or pieces, while hazelnuts would be cracked as a whole. Currently 10-20 100-kilogram bags are cracked for every family/farm every year (with approximately 5000 nuts per 100-kilogram bag). This takes the family 1-2 weeks to crack all the nuts. Our goal is to cut this time in half. It is important that the machine is usable by both women and children, and preferably be powered automatically over mechanically, if possible, to allow for ease of use.

### Sustainability Considerations

- Financial: The design needs to be affordable for small farmholders so multiple units can be purchased per farm.
- Social: Georgian social dynamics must be maintained, including traditional practices and jobs held by specific community members. The nut cracking process should involve all family members, and allow for social interactions to be upheld during nut cracking social activities.
- Environmental: The tool must keep up with the pace of nut production, and consider the growth of the nut-cracking industry (potential deforestation). Nut shell waste must be considered in the design. The design must also consider losses and waste from pulverization of the nut meat.

- Technical: The design must use locally sourced materials and be easily constructed. The machine process knowledge must be easily transferable, with operation known by all ages. The maintenance must be minimal and the design ergonomic.
- Safety: As children are likely users of the machine, it is critical that the machine be designed as safely for the user as possible, with minimal opportunity for injury.

Current technologies include motor powered crushers that use a rough bladed wheel to apply pressure to the nut against an adjustable ramp. Another prior art design uses a 2-piece rotating concrete cylinder and gravity to create friction to break the nut open. There are also large-scale industrial designs on the market that use motors to smash the nuts as well as separate shells from the nut. Price for the equipment varies between \$2500-\$4000. Small farmers are not able to afford this high price, so instead use women power as the main labor to break the nuts. A major challenge to the use of technical equipment is the maintenance costs and ability of the equipment to work with different size nuts, as they are collected from different species of trees.

### **Design Process and Methodology**

The design process began with consideration of prior art and current designs in the world market that met our client's needs. After gathering information from a variety of sources, our team decided between 2 designs, the wheel crusher and the concrete crusher. We evaluated both designs based on pros and cons, as shown below.

#### **Wheel Design**

- Pros: Common materials, cheap to build, can be powered by common electric screwdriver or by hand. Almost perfectly cracks hazelnuts every time. Adjustable ramp for nut sizes.
- Cons: Not yet complete, clogs (with walnuts), nuts get stuck
- This project is simple to build , affordable, and can be powered by hand or by easily accessible motors.

#### **Concrete Design**

- Pros: Common materials, cheap to build, already proven (for other types of nuts), durable, makes use of gravity.
- Cons: somewhat complicated to build for non builders, hand cranked, concrete can be damaged. Concrete must be poured perfectly. Heavy design.
- This project is affordable, sustainable, and adaptable. Its largest weakness is that it is fairly complicated to build (not simple to build but simple to use)

After conversing with our client and through our personal recommendations, we decided to prototype the wheel design first and build the concrete design if there was time. The design for the wheel crusher was based off of a small machine from Amazon, which was purchased for analysis. Walnuts and hazelnuts were acquired for testing purposes.

The main theory for the design involved using a rough wheel to crush nuts against a wall. For the wheel, we wanted fins or curved blades on a long axle. We considered placing semicircles on the rod, but settled on bar fins to allow for a stronger cracking edge to come in contact with the nuts. The nuts would be crushed against a wall that would be slanted to adjust for the size of the nut. This angle could also be adjusted based on different types of nuts. Instead of having the nut crushed against the edge of the wall to crack the nut, the wall side was made to be the crushing surface to reduce variable for error and specific calibration. The Amazon design incorporated all of these components, and we spent the rest of the quarter perfecting the design and rebuilding a larger version.

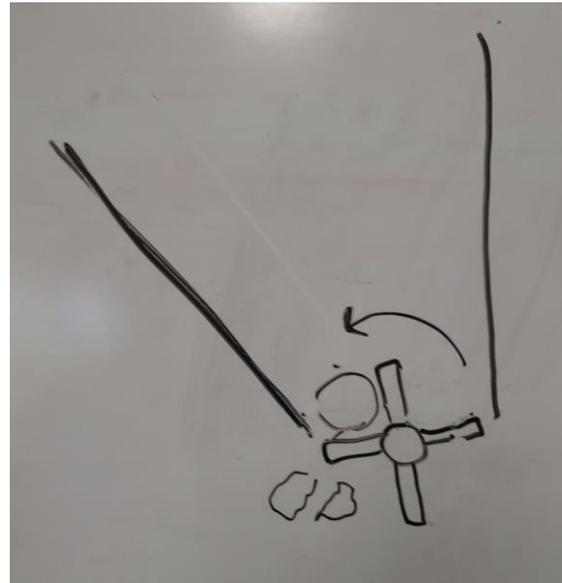
Some problems with the Amazon design included having too small of an exit chute for the broken nuts. The opening of the crusher allowed too many nuts to enter, which caused clogging and made the nuts pop up instead of getting crushed. The adjustable wall did not provide enough resistance to crush the nuts in some cases. We decided to recreate the entire design with these adjustments to make the design fit our clients needs more effectively.

We created a square housing for the crusher using a thin steel bar. The main difficulty in constructing the prototype was maintaining precision in placement between the spinning wheel, ramp bar and ramp adjustment components. We added 3 different positions for the ramp to be placed depending on the nut size. 2 adjustable bolts were added to provide more stability for pressure on the ramp. The crusher exit was widened, and legs were added to lift the crusher to provide room for the nuts to exit. For the wheel rod we built a bladed design from a hollow tube and 4 steel bars serving as fins. This component was built to be removable from a bolt and securable to a bolt during use. A locking screw held the blade in place during operation. This blade would be used for walnuts, while the blade provided in the ordered design would be used for hazelnuts since it was smaller. The bolt for the blades was intentionally made extra long to allow for attachment with a drill. This component made the design use a high torque to crush any nut and less exhaustive energy source for use. A plastic container was used as a nut hopper to house an amount of nuts to be crushed. This final design was built from steel flat bar, bolts, nuts, washers, plastic bottles and duct tape through drilling, sawing, welding and brazing.

## Design Criteria and Metrics

| Criteria                  | Qualitative/<br>Quantitative | Testing Procedure   | Target Value | Metric   | Evaluation hazelnut | Evaluation walnut  |
|---------------------------|------------------------------|---|--------------|--|---------------------|--------------------|
| Comfort                   | Qualitative                  | Focus group on comfort of design  | 9/10         | "comfortable"  | 8/10                | 8/10               |
| Adaptability (type)       | Qualitative                  | Ability to crack different types of nuts                                | Yes          | Hazelnut and Walnut successful cracking                        | Yes                 | Yes                |
| Adaptability (strength)   | Qualitative                  | Reports ability to adjust crushing mechanism                            | Yes          | Size adjustment  | Yes                 | Yes                |
| Sustainable Energy Source | Qualitative                  | Focus group report on long-term strain of use and availability of power | 5/5          | People say "not straining" and "doesn't waste too much energy" | 5/5                 | 5/5                |
| Size                      | Qualitative                  | Focus group report on ability to fit inside shop                        | 5/5          | Target consumers say it is "a good size"                       | 5/5                 | 5/5                |
| Sorting ability           | Quantitative                 | Removes shells from nut   | 95%          | Volume   | N/A                 | N/A                |
| <b>Accuracy</b>           | <b>Quantitative</b>          | <b>Machine preserves nut without fracturing</b>                         | <b>95%</b>   | <b>Nuts not broken/crushed</b>                                 | <b>50% cracked</b>  | <b>84% cracked</b> |
| Weight                    | Qualitative                  | Focus group reports on ability to transport                             | 5/5          | People say "it is not too heavy"                               | 5/5                 | 5/5                |
| Affordability             | Quantitative                 | Project cost is within budget   | <1500        | USD  | <50                 | <50                |
| Simplicity                | Qualitative                  | Focus group reports on ease of material acquisition and construction    | 4/5          | People say "it is not hard to build"                           | 4/5                 | 3/5                |
| Throughput                | Quantitative                 | Nuts cracked by machine   | >.5          | kg/min   | 1.17 kg/min         | .667 kg/min        |
| Capacity                  | Quantitative                 | Nuts held by machine  | >1000        | nuts   | 500 nuts            | 80 nuts            |

## Results, Discussion and Conclusions



Once our design was completed, we conducted tests to see if our design produced results that were within the needs of our client. The entire design, considering materials, labor and building materials, was priced at \$50, which is well within the needs of our client. We performed 3 tests: capacity, accuracy and throughput. The results of these tests can be found in our criteria table above. The design relies heavily on the angle of the crushing ramp, which has a great effect on the percentage of nuts cracked in each run of the machine. Cracking 1500 kilograms of hazelnuts would take one worker 6.1 days of work, considering a 7 hour work day. Cracking 1500 kilograms of walnuts would take one worker 6.4 days of work, considering a 7 hour work day. These times do not take into consideration time to refill the nut hopper and time to sort the nuts from the shells. Using more people and more machines would further reduce this time. This rate of reducing the time by half is within the needs of our client. These times consider the crushing accuracy of the machines. Further ramp angle and drill speed adjustments can further reduce the time required for crushing. Nut crushing accuracy will have to be improved until the client's maximum nut loss percentage is reached. Adjustments will also reduce the percentage of nuts that are not completely cracked while growing the percentage of nuts that are fully cracked, reducing losses and producing higher value products. Especially for walnuts, the cracking ability will need to be perfected to emphasize whole nuts over small pieces.

Our finished design had a problem crushing walnuts due to the nut on nut friction preventing the nuts from falling into the crushing blade. The walnuts were predominantly broken up into small pieces, and rarely broken in half. This may not be ideal for our client, as halves are more valuable products.

## **Recommendations**

The design has many areas for improvement. More tests could be completed to determine ideal levels of ramp adjustment for each type of nut, and ideal speed of the drill motor. A more durable nut hopper with controlled nut input could be constructed, possibly including a ramp that only allows one nut to be crushed at a time. A solid frame could be made for use in a vice during operation to reduce design movement from drill torque. A collection ramp for nut pieces could be made, and a separation sifter could be developed as an additional mechanized step to separate nuts from their shells. A tension and compression spring could be added behind the adjustable ramp to provide pressure adjustment during use of the machine. Increased safety measures could be made to prevent possible harm to the user. It would also be useful to research potential markets or applications for the wastestream (nut shells) that may increase farmer revenue. We need to consult our client to gain more specific safety needs, social needs and accuracy needs.

## **Bibliography**

UC Davis D-Lab. "Nut Breaker Tool, Georgia". Project Brief.

## **Appendix**

See design notebook for all Deliverables. See link to this Google Drive folder:

<https://drive.google.com/drive/folders/1EXsl0M8JI7U9danodIM5ZvflxaVuThfX?usp=sharing>