Documentation of Ten most Outstanding Innovations in Zambia

Zambia Agriculture Research Institute

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Program of Accompanying Research for Agricultural Innovation

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<table>
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<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>ACF</td>
<td>Agricultural Consultative Forum</td>
</tr>
<tr>
<td>CCPC</td>
<td>Consumer Competition and Protection Commission</td>
</tr>
<tr>
<td>CFU</td>
<td>Conservation Farming Unit</td>
</tr>
<tr>
<td>CIMMYT</td>
<td>International Maize and Wheat Improvement Centre</td>
</tr>
<tr>
<td>COMACO</td>
<td>Community Markets for Conservation</td>
</tr>
<tr>
<td>EWAS</td>
<td>Empowering of Women through Agricultural Support in Southern and Western Provinces Project</td>
</tr>
<tr>
<td>FAO</td>
<td>Food and Agriculture Organisation of the United Nations</td>
</tr>
<tr>
<td>FISP</td>
<td>Farmer Input Support Programme</td>
</tr>
<tr>
<td>GMO</td>
<td>Genetically Modified Organism</td>
</tr>
<tr>
<td>HQCF</td>
<td>High Quality Cassava Flour</td>
</tr>
<tr>
<td>IITA</td>
<td>International Institute for Tropical Agriculture</td>
</tr>
<tr>
<td>ILUA</td>
<td>Integrated Land-Use Assessment</td>
</tr>
<tr>
<td>IPs</td>
<td>Innovation Platforms</td>
</tr>
<tr>
<td>MoH</td>
<td>Ministry of Health</td>
</tr>
<tr>
<td>NAIS</td>
<td>National Agricultural Information Services</td>
</tr>
<tr>
<td>NCDS</td>
<td>National Cassava Development Strategy</td>
</tr>
<tr>
<td>NFNC</td>
<td>National Food and Nutrition Commission</td>
</tr>
<tr>
<td>NISIR</td>
<td>National Institute for Scientific and Industrial Research</td>
</tr>
<tr>
<td>NPASC</td>
<td>National Pro-vitamin A Orange Maize Steering Committee</td>
</tr>
<tr>
<td>PAM</td>
<td>Program Against Malnutrition</td>
</tr>
<tr>
<td>ppm</td>
<td>Parts per million</td>
</tr>
<tr>
<td>SCCI</td>
<td>Seed Control and Certification Institute</td>
</tr>
<tr>
<td>SI</td>
<td>Statutory Instrument</td>
</tr>
<tr>
<td>TDRC</td>
<td>Tropical Diseases Research Centre</td>
</tr>
<tr>
<td>UNICEF</td>
<td>United Nations Children’s Fund</td>
</tr>
<tr>
<td>UNZA</td>
<td>University of Zambia</td>
</tr>
<tr>
<td>USAID</td>
<td>United States Agency for International Development</td>
</tr>
<tr>
<td>ZABS</td>
<td>Zambia Bureau of Standards</td>
</tr>
<tr>
<td>ZAMSEED</td>
<td>Zambia Seed Company</td>
</tr>
<tr>
<td>ZARI</td>
<td>Zambia Agriculture Research Institute</td>
</tr>
<tr>
<td>ZASTA</td>
<td>Zambia Seed Traders Association</td>
</tr>
<tr>
<td>ZENGO</td>
<td>Zambia Energy and Environmental Organisation</td>
</tr>
<tr>
<td>ZNFU</td>
<td>Zambia National Farmers Union</td>
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</tbody>
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Synopsis of Studies

A. Name of Innovation: “Promotion of Pro-vitamin A (Orange) Maize for Improved Nutrition”: Market-share under the Farmer Input Support Programme during the 2015/16 Agricultural Season

1. Background:

From nutritional studies undertaken as far back as 2003, Zambia’s population has had high incidences or prevalence of Vitamin A deficiency, of about 54%, particularly among the young children, according to a 2003 monitoring survey undertaken by the National Food and Nutrition Commission (NFNC) and other stakeholders. The most vulnerable/prone are the under-five children, lactating mothers and pregnant women, predominantly in rural areas. With this empirical realization, Government’s policy has been to address this situation through the promotion, provision and encouragement of increased intake of Vitamin A. Thus initially this policy actualization started and has still continued with the encouragement and emphasis on people to have a balanced diet. Subsequently in May 1998, fortification of household sugar with Vitamin A was introduced and mandated by the Government through a Statutory Instrument number 155 (SI 155). However, this SI excluded fortification of industrial sugar. Fortification was undertaken/implemented through the then only private sugar company, Zambia Sugar Company Plc.

In the late 2000’s other options of Vitamin A sources (bio-fortification) were explored and implemented. Before embarking on bio-fortification, the mandate of fortification (through SI 155) of all household sugar produced and sold in the Country led to the banning of all imports of unfortified sugar. The National Food and Nutrition Commission (NFNC) also established the Sugar Fortification Technical Committee in 2000 and in the same year the Ministry of Health started the enforcement of the sugar fortification mandate.

The enforcement of sugar fortification mandate resulted in excessive increment of sugar prices by the then sole sugar producing company (Zambia Sugar Company), to the disadvantage of the rural and poor vulnerable sugar consumers; with implications of exacerbating the Country’s Vitamin A deficiency.

Although later on other private sugar processing companies emerged (such as the Kasama Sugar and Kafue Sugar Companies), the fortification enforcement created a monopoly of the local sugar market by Zambia Sugar Company, which was the only company which had the facilities for fortification.
By 2008 sugar prices increased by as much as 150% due to fortification. This led to the Economic and Labour Committee of the Zambian Parliament to recommend or advocate for the reversal of the sugar fortification policy in 2009, in order to enhance competition. However, the NFNC defended the fortification policy.

A number of studies undertaken e.g. by the Agricultural Consultative Forum (ACF) in 2012 (Chisanga et al. 2014) and the University of Zambia (UNZA) by Kalinda and Chisanga (2012) found out and/or concluded that Zambia Sugar Company enjoyed the sugar monopoly power, thereby reducing competition and resulted in high sugar prices; and that sugar fortification constituted a form of non-tariff barriers.

One of the alternative sources of Vitamin A embarked on, as mentioned above, was the breeding and production of Orange Maize (Pro-Vit. A Maize) by the Zambia Agriculture Research Institute (ZARI) of the Ministry of Agriculture. HarvestPlus sourced for varieties from CIMMYT in 2007 and approached ZARI with regard to the breeding of rich vitamin A Orange Maize. Subsequently, in 2010, an Innovation Platform (IP) called the National Pro-vitamin A Orange Maize Steering Committee (NPASC) was formed aimed at promoting the production, encouraging and supporting the processing and selling of orange maize in form of mealie-meal. Initially the NPASC Innovation Platform covered only seven (7) Districts, namely Chipata, Katete, Petauke and Nyimba (in Eastern Province) and Choma, Kalomo and Monze (in Southern Province), but now covers the whole Country.

Through the efforts of the IP, Orange Maize seed was officially launched in Zambia by the Minister of Agriculture (August 2015) and the crop was included in the Ministry of Agriculture’s input subsidy Programme, called the Farmer Input Support Programme (FISP) in the 2015-2016 Agricultural Season.

2. **Projected pathway to generation of solution:**

Besides the traditional/usual way of teaching and/or promoting and encouraging the consumption of a balanced diet (consisting of adequate vitamin A foodstuffs), the problem of Vitamin A deficiency among the Zambian population is currently being addressed through the following ways or efforts:

- Fortification of processed cane sugar;
- Production and consumption of orange maize (Pro-vitamin A maize);
- Administration of “high” dosage of Vitamin A (medical treatment);
- Breeding and production of orange-fleshed sweet potatoes; and
- Breeding and production of yellow-fleshed cassava roots.

3.1 **Vitamin A fortification of processed household Cane Sugar:** As mentioned in the background, above, fortification of all household cane sugar for selling in Zambia was made mandatory through SI 155 in 1998, leading to the ban of importation of all non-fortified sugar. The then sole producer of cane sugar in Zambia, the Zambia Sugar Company, was assisted to procure the required facilities/equipment for fortification. Thus, it is a legal requirement that
every cane sugar produced and sold in the Country for human consumption should be fortified with Vitamin A. Therefore, all the sugar produced in Zambia by Zambia Sugar Company (the major sugar producing private company) which produces over 90% of the Country’s sugar, including the other smaller private producers, such as Kasama Sugar Company and Kafue Sugar Company, is fortified with Vitamin A.

Sugar fortification with Vitamin A has had and continues to generate mixed, serious and complex debates among various stakeholders. Some of the opposers’ (e.g. individual larger sugar consumers, Economic & Labour Affairs Parliamentary Committee, and researchers from Indaba Agricultural Policy Research Institute, UNZA, ODI and ACF) main arguments include: (i) that fortification has marginally reduced the Country’s vitamin A deficiency among the young children from 66% to 54%, according to the two national monitoring surveys undertaken in 1997 and 2003, over the same period: fortification showed no significant contribution to the reduction of Vitamin A deficiency according to the 2003 Report of Partners, (ii) fortification reduces competition and encourages monopoly, (iii) as a result of monopoly, fortification leads to high sugar prices, and (iv) fortification mandatory policy is a form of a non-tariff barrier to trade.

On the other hand, the advocates of vitamin A fortification (i) enjoy huge financial benefits from the high sugar prices (i.e. the private sugar companies); besides arguing (ii) that fortification is a least cost programme to the Government, and (iii) that there are other factors contributing to the poor response of Vitamin A fortification to the reduction of vitamin A deficiency such as malaria.

In this fortification debate there are also indifferent (neutral) stakeholders such as the Consumer Competition and Protection Commission (CCPC), Zambia Bureau of Standards (ZABS) and the Seed Control and Certification Institute (SCCI).

3.2 Production and consumption of Orange Maize (Pro-vitamin A maize): ZARI in collaboration with HarvestPlus started breeding of orange maize varieties in 2007-2008 agricultural season, initially aiming at breeding maize with 15ppm of inherent Vitamin A. By 2009, however, it appeared difficult to attain this level of Vitamin A, thus with HarvestPlus’ recommendation the target was reduced to 7.5ppm in order to show quick results. In 2013 ZARI released and registered three (3) Orange (Pro-Vit. A) Maize hybrid varieties, namely, GV 662A, GV 664A and GV 665A, and respectively licensed them for commercialization to Kamano Seed Company, Zambia Seed Company (ZAMSEED) and SeedCo, (all private seed companies). Three more varieties were again released in 2015, i.e. GV 671A, GV 672A and GV 673A.

Apparently, many Zambians are appreciating the nutritive value of orange maize, especially for its inherent Vitamin A and that it is not a Genetically Modified Organism (GMO) product, as compared to using chemically fortified food stuffs.

Through the efforts of the established IP for the Orange Maize, the crop was officially launched by the Minister of Agriculture in 2015 and for the first time, in the 2015/2016
Agricultural Season, Orange Maize was introduced in the Government’s subsidy input pack of the FISP.

In 2015, an accumulated number of 104,000 small-scale farming households were said to be growing and consuming orange maize and had attained a total production of 37,500 MT, with 500 MT of planted seed over an area of 25,000 Ha. The IP indicated that in the same year it promoted Orange Maize for consumption by 520,000 household members. The target is to have 500,000 small scale farmers producing/growing the crop by the year 2020.

However, it had proved challenging to convince most Zambians to start consuming orange maize because of the previous experience with the yellow maize during some years/periods in the Second Republic and in the early Third Republic (i.e. between 1985-1990 and 1991-1992, respectively): yellow maize had an unfavourable taste and bad odour rancid smell; apparently due to long storage and fumigation. The IP worked very hard to convince consumers with the branded ‘Orange’ maize as opposed to the previous ‘Yellow’ maize. Even the Office of the President had to confirm with ZARI in 2013 (following the release of the first orange maize varieties) as to whether the Orange maize was not a GMO (to get official government recognition).

The promotion of Orange Maize for improved nutrition in addressing the problem of Vitamin A deficiency in the Country is the most logical pathway to the solution (refer also to Table 1, looking at the Government’s side). This pathway has a number of advantages as compared to the other means, some of which are outlined or elaborated below:

a) Utilization of maize is easy because the crop is Zambia’s staple food crop and is grown throughout the Country and predominantly by small-scale rural-based farmers, who also constitute the largest proportion of the farmers’ category. Thus orange maize if promoted would readily be available to the Vitamin A-deficient rural and poor vulnerable communities.

b) Since orange maize seed has been included in the Government’s input subsidy programme (FISP) which is a countrywide programme, the seed/crop would be available or accessed throughout the Country.

c) With the planned acquisition of facilities for undertaking the Double Haploid (DH) Approach/Technology by ZARI, it would be quicker for ZARI and generally the Country to produce orange maize inbreed lines and subsequent release of new varieties. DH methodology would also lessen the cost of maize breeding in the long-run (currently ZARI uses Kenya’s DH facilities and services, which is costly).

d) With intensified extension service provision and enhanced awareness creation by the IP, concerning the goodness of orange maize, most farmers and consumers are appreciating and accepting the crop. Additionally both adults and children are appreciating orange maize compared to white maize, not only because of its nutritive value but also because of its sweeter taste. The released varieties of orange maize have also been bred for early maturity, drought tolerance and disease resistance.

e) Besides the general improvement in the health status of people, it has resulted in reduced public expenditure on provision of health services.
3.3 **Breeding and production of Orange-fleshed Sweet Potatoes:** Breeding of orange-fleshed sweet potatoes is one other pathway addressing vitamin A deficiency, which ZARI embarked on in the early 2000s. So far ZARI has released six (6) varieties of orange-fleshed sweet potatoes (2 in 2003 and 4 in 2015). However, as compared to orange maize, sweet potatoes are not generally grown in all parts of the Country and are rather seasonal and not a staple food crop; thus it is less available and not consumed widely.

3.4 **Breeding and production of Yellow-fleshed Cassava Roots:** Much as cassava (white-fleshed) breeding and production is an old practice in Zambia, production and promotion of yellow cassava roots is an upcoming effort of addressing the Vitamin A deficiency problem in the Country. Yellow-fleshed cassava root production and promotion is thus a promising technology for becoming an innovation. ZARI has embarked on researching it and research trials are now moving onto field trials in the 2016-2017 Agricultural Season. Cassava is the second staple food crop in Zambia and has also been promoted for commercialisation as an industrial crop. Thus this pathway of vitamin A deficiency solution is quite promising once it attains its full scale.

Table 1 below shows some of the advantages and disadvantages of the above described pathways of addressing the problem of vitamin A deficiency, from the Zambian Government’s perspective:
<table>
<thead>
<tr>
<th>S/N</th>
<th>Vitamin A Provision Pathway</th>
<th>Advantages</th>
<th>Constraints</th>
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</thead>
</table>
| 1   | Bio-fortification            | ✓ One-time research cost  
     |                             | ✓ Continued lower recurrent cost of seed certification after initial release of new varieties  
     |                             | ✓ Available/provided pro-vitamin A is converted by human body to Retinol as required, thus avoiding over-dose  
     |                             | ✓ Besides the NFNC and/or Ministry of Health, other ministries are also involved in nutrition policy generation and implementation |            |
| 2   | Mandatory Vitamin A Fortification | ✓ Implemented by private Sugar companies  
     |                             | ✓ Government only enforces and monitors  
     |                             | ✓ Cost is borne by the consumer (i.e. consumer pays for the programme) | ✓ Competition is reduced through import bans, thus risks pricing the poor out of the market  
     |                             |                                                        | ✓ Encourages/promotes market monopoly by bigger local companies, leading to higher commodity prices  
     |                             |                                                        | ✓ Likelihood of leading to exclusion of the need/vulnerable groups (rural and poor) due to price inflation |
| 3   | Vitamin A Supplementation    | ✓ Directly delivered to the target (vulnerable) groups | ✓ Direct administration/delivery of pure Retinol leads to potential overdose  
     |                             |                                                        | ✓ All costs of supplementation are borne by the Government and donors  
     |                             |                                                        | ✓ High manpower costs to run the Programme |
3. **Innovation Description:**

The promotion of Orange (pro-vitamin A) Maize for improved nutrition to address the prevalence of vitamin A deficiency, especially among pregnant women, under-five children and lactating mothers, in Zambia and its market-share under the Government’s agricultural input subsidy programme (Farmer Input Support Programme-[FISP]), is both a technical and institutional innovation.

The technical category of the innovation involves the breeding of orange maize by ZARI in Zambia, using varieties which were supplied to HarvestPlus by the International Maize and Wheat Improvement Programme (CIMMYT). The maize from CIMMYT is bred locally for domestication and adaption to Zambia’s agro-ecological conditions and character/trait preferences and suitability. The breeding process leads to the release of local varieties of orange maize seed by ZARI and registering them with the Seed Control and Certification Institute (SCCI), for local use.

On the other hand, the institutional/organisational category of the innovation involves the collaboration of HarvestPlus and ZARI in the sourcing and breeding of the primary orange maize variety; the registration of the locally released varieties by ZARI with SCCI and the licensing of the released varieties to the local private seed companies for commercialization.

The other aspect of institutional innovativeness comes in the creation of an Innovation Platform (NPASC) to promote the Crop’s production by farmers and consumption by the public. The institutional category of the innovation also is with regard to the working of the IP in the promotion of the Crop for official recognition and acceptance by the Government, leading to the Crop’s inclusion in the FISP, for countrywide production by small-scale farmers and also the enticing of private companies (millers) to process the crop into mealie-meal for public market and utilization.

The technical aspect of the innovation takes advantage of the inherent vitamin A in the maize variety, to breed it for production and human consumption instead of using chemical fortification of Vitamin A into foodstuffs.

The innovation takes advantage of maize being the staple food crop and grown throughout the Country by all categories of farmers, especially by the majority producer category-the small-scale farmers; and who are also predominantly rural-based. The nature of this pathway, i.e. the Crop produced, processed and utilized/consumed countrywide, therefore gives this innovation both a comparative and competitive sustainability advantage in terms of social acceptability, environmental suitability, including relative economic benefits.

Nevertheless, the innovation initially posed a big challenge with regard to its social acceptability by the public due to the previous experience encountered in the late 1980s and/or early 1990s with the yellow maize (as pointed out in Section 3.2, above). This drudgery, however, is slowly being overcome due to the efforts of the IP in awareness creation and the general public’s appreciation of the nutritive value of the orange maize and also its sweeter taste. The other concern from farmers is that orange maize has smaller grain-size compared to white maize: the farmers thus are finding it labourious when shelling (hand-shelling) and that more grains are required to fill up the same volume of maize bag (the standard 50 Kg bag) compared to white maize. However, the issue of the small grain-size has
already been raised and ZARI is thus working on this characteristic with the aim of increasing the size.

Cobs of Orange Maize

4. Economic Feasibility /Benefits:
The economic feasibility of the innovation, in this case is looked at in terms of the market-share of orange maize compared to white maize under FISP.

Zambia has predominantly been a white maize producing and consuming country since the pre-independence era. Thus orange maize at its first introduction and only supplied by three companies from its first three locally released varieties, attaining a 5% market share under FISP (as shown in Figures 1 and 2 above) is a good and positive indicator of a promising market share.
In fact, the five percent share was not, in the strict sense, a market-determined share, but a Government decided share to be included under FISP, as a beginning. The Country market-share of orange maize was/should actually be more than 5%, if the orange maize seed supplied to farmers by the three licensed companies (Kamano Seed Company, ZAMSEED and SeedCo), using other private retail and wholesale seed outlets, including the respective Companies’ own seed outlets throughout the Country are taken into account. Figures 3 and 4; and Tables 2 and 3, below show the numbers and names of the various private companies that supplied both white and orange seed maize by quantity (in Metric Tons), percentage of total and varieties of orange maize seed under FISP during the 2015-2016 agricultural season.

![Chart Title](image)

**Figure 3: FISP Total Maize Seed Supply by Type & Supplier (2015-2016)**

![Figure 4: Proportion and Number of Suppliers by Type of Maize Seed](image)
5. **Scalability:**

Orange maize has high potential for scaling up and scaling out, as could be seen in the initial (first year) supply under FISP by only three companies, in which all the total seed supplied was purchased by the targeted small-scale farmers. This is considering that other uncertain/unknown quantities of seed were supplied by the three (3) Companies through the various private retail and wholesale seed supplier outlets, including their respective own seed outlets, throughout the Country.

From the observed demand in the 2015-2016 Agricultural Season under FISP, it is expected that in the coming 2016-2017 and subsequent agricultural seasons, increased quantities of orange maize would be supplied to farmers for production. The target number of beneficiaries under the FISP in the 2016-2017 Agricultural Season is 1,000,000 small-scale farmers. The quantity supplied is further expected to increase once the other (new) three additional varieties released by ZARI in 2015 are licensed to either the same or other private seed companies for commercialisation. Potential for scaling up and out is further higher in that maize, being the staple food crop is grown and consumed throughout the Country. Orange maize is also apparently being preferred to white maize not only for its nutritive value (Vitamin A) but also for its sweeter taste.

In the 2016-2017 Agricultural Season, the Input Pack for orange maize to be supplied under FISP would be the same as that for white maize; and costing the same (K400.00 per pack).

With Zambia being the only Country among its neighbours and other nearby countries in the Region, which had a higher (bumper) maize harvest in the 2015-2016 Agricultural Season, surplus maize, which probably include orange maize, found itself in neighbouring countries (legally and illegally).

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**Table 2: Summary of Maize Seed Supplied & Suppliers**

<table>
<thead>
<tr>
<th></th>
<th>Type of Maize</th>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>White</td>
<td>Orange</td>
<td>Total</td>
<td></td>
</tr>
<tr>
<td>No. of Suppliers</td>
<td>8</td>
<td>3</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>% of Suppliers</td>
<td>100</td>
<td>37.5</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Total Seed Supplied</td>
<td>1,625.72</td>
<td>77.60</td>
<td>1,703.32</td>
<td></td>
</tr>
<tr>
<td>% Seed Supplied</td>
<td>95.4</td>
<td>4.6</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

**Table 3: Variety of Orange Maize Seed by Supplier**

<table>
<thead>
<tr>
<th>Supplier</th>
<th>GV 662A</th>
<th>GV 664A</th>
<th>GV (SC) 665A</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>ZAMSEED</td>
<td>0</td>
<td>2.86</td>
<td>0</td>
<td>2.86</td>
</tr>
<tr>
<td>Kamano Seed</td>
<td>73.74</td>
<td>0</td>
<td>0</td>
<td>73.74</td>
</tr>
<tr>
<td>Seedco</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Total (MT)</td>
<td>73.74</td>
<td>2.86</td>
<td>1</td>
<td>77.6</td>
</tr>
</tbody>
</table>

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B. Name of Innovation: “Use of Solar-powered Drying Machine for Cassava”: impact in Senanga & Gwembe Districts

1. Background:
Cassava is the second staple food crop for Zambia, which is primarily grown by small-scale farmers largely for domestic human consumption. The Crop is mainly grown in four provinces namely, Luapula, Northern, Muchinga and Western. The Government is showing appreciable interest and commitment in promoting cassava not only for human consumption but also for industrial use, by trying to commercialise the crop. The commitment even led to the development of the National Cassava Development Strategy (NCDS).

The Program Against Malnutrition (PAM), an NGO, has also for a long time been promoting Cassava production in the Country among small scale farmers for food and nutrition security. With the overall aim of contributing to the attainment of the Country’s food and nutrition security, PAM started the Empowerment of Women through Agricultural Support Project (EWAS) in 2012. The Project is now in its second phase (September 2015-August 2017), being implemented in two (2) districts, namely Senanga and Gwembe (Western and Southern Provinces, respectively). In achieving its goal, EWAS Project introduced and is promoting the Solar-powered Drying Machine for Cassava, in the above mentioned 2 operating Districts. Gwembe and Senanga Districts were selected as target districts, being among the areas prone and highly affected by climate change (receives poor/very little rains; rather prone to drought) and thus being among the highly poverty stricken areas of the Country (with low crop, particularly maize, production), especially during the dry seasons. Thus in order to achieve the Project’s aim/goal these areas were found to be ideal. However, the Districts are naturally endowed with a number of abundant natural fruits, e.g. Mangoes (Mangifera indica) and Masuku (Uapaca Kirkiana).

The Project therefore encourages women (target beneficiaries) to grow and dry cassava for consumption and income generation (EWAS Project aims to particularly empower women). Besides cassava, the Project also encourages its beneficiaries to also grow and dry vegetables and fruits, using the same solar-powered drying machine, for consumption, especially during off-seasons. Thus, under the EWAS Project, PAM bought the Solar-powered Drying Machines from Dr. I N. Simate (the Machine Designer and Fabricator) and supplied to its beneficiaries. Currently the Project has supplied sixty (60) of these machines to each of the two Districts: that is, each target Women Group (comprising 15 to 30 individual members) in each district is provided/given one Dryer.

The technology of the Solar-powered Drying Machine was designed and initiated by Dr. Simate as his Doctor of Philosophy (PhD) project thesis. The development of the technology/innovation was as a result of his interest in food processing. After completion of his PhD, Dr. Simate fabricated another solar-powered drying machine for his household drying/preservation of fruits, such as mangoes. This aroused the interest of neighbors,
other people and institutions who then requested him to make and supply them with the same machine. And apparently, there is high demand for the machine and service not only in Lusaka, but also in other parts of the Country; thus besides PAM, Dr. Simate has fabricated and is still fabricating and selling the solar-powered drying machines to various people and organisations in different parts of Zambia. For instance the International Institute for Tropical Agriculture (IITA) has also bought the machines- being used in Mansa, Mumbwa and Livingstone Districts.

Although the innovation is referred to as ‘Use of Solar-powered Drying Machine for Cassava’, the Machine/Dryer can be or is used to dry other various foodstuffs, which require drying, e.g. crops (including fruits and vegetables), fish, meat, grains etc. It is thus a multipurpose food-drying machine.

Therefore, under the PAM’s EWAS Project the beneficiaries’ various own dried agricultural products are consumed by themselves and also sold to other people for income generation. Additionally, the beneficiary women groups also generate income from the innovation by providing a service to other community members within the districts, through the use of the machine for drying agricultural products at a fee.

The innovation has thus improved the livelihoods, particularly of the EWAS Project’s beneficiaries, by enhancing food and nutrition security, increasing incomes and saving labour and time.

2. **Projected pathway to generation of solution:**

There are various ways of drying agricultural crops for the purpose of preservation. These include:  
(i) open-air drying, mostly taking advantage of or utilizing the shining sun (common method especially in rural areas), (ii) using various types/forms of electrically operated machines/facilities/equipment (more common in urban areas), and (iii) use of the solar-powered drying machine (recent and not so common, and is applicable/suitable in both rural and urban areas).

The open-air drying also takes various forms such as putting the crop (including fruits cut into smaller pieces) on:

a. rooftop-tops: mostly on roofs made from either grass or iron sheets.

b. the ground: Normally the crops to be dried are put on various materials e.g. plastic sheets, flat metal sheets, empty grain bags/sacks, plain paper sheets, carton sheets etc.

c. raised flat wooden platforms/tables: Normally these tables are made from planks/timbers or round tree poles. Even in this case, the crops are normally put on top of materials as mentioned in (b) above, which are laid on the raised platforms.

The open-air drying is predominantly used by the rural poor communities. This is the cheaper pathway among the three methods mentioned above. With this method, normally the crops being dried are not covered but directly exposed to the air and/or sun. Thus, the produce are exposed to dust and pets, such as chickens, goats, dogs, etc.

The electrical (probably including the gas) drying appears to be more advantageous compared to the open-air drying in that usually the dried products are covered and thus hygienic. However,
this is disadvantageous to or is/may not be used by people in areas where electricity is not available; as is common in most rural Zambia. Additionally, besides the initial cost/investment in the drying apparatus/equipment, the running costs e.g. electricity bills, may be high; especially with the general realization that the quantity dried at a go with this method is normally small and usually one item (foodstuff) is dried at a time.

The logical pathway to drying of crops is thus apparently the third method, the “use of the solar-powered drying machine innovation”. This is seen from the following considerations:

- The machine can be used to dry various agricultural products/crops, i.e. fruits, vegetables, meat, fish, grains etc.
- Solar power or energy is available everywhere (rural and urban) and adequate (if not more than abundant) to meet the machine requirement for drying, in the Country;
- Solar power or energy is available almost throughout the whole year in almost all parts of the Country;
- The solar-powered machine is easy to operate and/or is rather both-gender friendly;
- While drying, the food is covered and thus not exposed to dust or pests; making the innovation hygienic.
- Although the initial cost of or investment in the machine may be high (currently ranging from K1,500 to K20,000, depending on the size), the running costs are quite low and the machine is easy to maintain; maintenance costs may be generated by the innovation by offering the drying services to other people/communities (as is the case with the EWAS Project beneficiaries). The current reliable income being generated by the innovation is through the supply of various dried foodstuffs to several government schools, under the World Food Programme (WFP)’s School-feeding Programme (there is a signed MoU between the Project Groups and WFP for this Programme).
- The beneficiaries of the EWAS Project are just provided with the machines as a grant, and so they have not incurred any procurement costs, and the machines are expected to be running for some time (although the normal life-time is yet to be established).

3. **Innovation Description:**

   The use of a solar-powered drying machine is a technical innovation and modern. The Solar-powered drying machine is an equipment which has a platform on which trays are put. There are two types of trays used, depending on the type of foodstuffs being dried: one made of galvanized wire mesh fixed on a metallic frame and the other made of a silver metal sheet. The foodstuffs on the trays are covered with a plastic (polythene) net covering. The whole platform of the drying machine (made of iron sheets) on which trays are put/laid is covered with a green-house plastic which is exposed to sunlight. When putting the trays on the platform the green-house plastic is removed (half-way). One part or half of the platform (along the length of the drying machine), which is near or towards the end where the fan is located, is painted black so as to absorb the heat for drying. A fan and a switch are fitted on one of the width of the drying machine. The fan is driven by electricity generated by the solar panel, when the machine is switched on, that is, the sun shines on the solar panel which then generates electricity (D.C. electricity) to
run/energize the motor (within the fan) which propels the fan to blow/draw air onto the foodstuffs to be dried. The fan is connected directly to the solar panel (no batteries). The fans used for drying are the twelve voltage (12V) types/sizes.

Drying of the foods is both by the (hot) air from the fan and also from the sunlight heat coming directly through the green-house plastic covering the machine on top of the trays, i.e. two way drying/heating. Photos below show the solar-powered drying machines given to women clubs under PAM’s EWAS Project.

Left & Right: The 5m x 2m type of Solar-powered drying machines (mounted)

The Fan of the Solar Food Dryer

The Box containing the Switch for the Solar food Dryer
Left: One type of trays used in the Solar-powered dryers. Right: Same tray with a plastic mesh/net for covering food stuffs.

Left: Another type of tray used in the Solar-powered dryers. Right: Same tray with dried food covered with a plastic mesh/net.
The food stuffs to be dried are cut or chopped into small pieces, put/laid on the trays and covered by a plastic sheet (green house type). When the machine is switched on, the fan propelled by electricity directly generated from the solar panel, blows the air onto the foodstuffs to dry them; at the same time the sun shining directly on the plastic sheet covering the machine (on top of the trays) heats/dries up the food.

The food to be dried is protected from flies (insects), dust, rain, etc. by the green house plastic cover and the wire mesh which makes the width of the machine, opposite the fan. Additionally the food is protected on the trays by the black plastic net. Thus the food dried by this innovation is of good quality.

The machine is easy to operate (all-gender friendly) because once the switch is turned on, the fan runs on its own, with the speed of the fan determined by the intensity of the sunlight. That is, the more the sun the higher the speed of the fan and vice versa. And in this way, the temperature is self-automated or self-regulated: higher fan speed, more air (cool) from outside is drawn inside the machine and the cool air thus reduces the inside temperature and vice versa. As long as there is enough sunlight and the machine is switched on, drying of food stuffs can be done anytime.

There are currently four (4) different types of solar-powered food drying machines being manufactured/fabricated, by size, as indicated in Table 4:

<table>
<thead>
<tr>
<th>S/N</th>
<th>Size (Dimensions in metres)</th>
<th>No. of Trays</th>
<th>Electric Power of Solar Panel (Watts)</th>
<th>Quantity of Food [possible maximum], i.e. sliced (Kg)</th>
<th>[Current] Cost of Machine (K)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>20m x 2m</td>
<td>24</td>
<td>50</td>
<td>300</td>
<td>20,000</td>
</tr>
<tr>
<td>2</td>
<td>10m x 2m</td>
<td>12</td>
<td>40</td>
<td>150</td>
<td>13,000</td>
</tr>
<tr>
<td>3</td>
<td>5m x 2m</td>
<td>6</td>
<td>30</td>
<td>75</td>
<td>6,500</td>
</tr>
<tr>
<td>4</td>
<td>1.5m x 0.8m (Domestic)</td>
<td>10</td>
<td>10</td>
<td>1</td>
<td>1,500</td>
</tr>
</tbody>
</table>

The 5m x 2m type is the one on high demand. This is also the type which has been procured under the PAM’s EWAS Project and provided to the women groups in Gwembe and Senanga Districts.

The machine can be used for drying a number of different agricultural products. Although the machine has more than one tray (see Table 4) on which food to be dried can be put/laid, implying that many/different food types can be dried at the same time, however, only one type of foodstuff is dried at one time, to avoid smell from one food type affecting the other (like ‘smell-contamination’ of one food type with another). Thus the users assign different times to drying of different food types, i.e. only one food type is put on the tray(s) for drying at one time. Thus the EWAS Project beneficiaries have assigned different days to the drying of different food types,
such that even if more than one tray is used, all the trays will have only one type of foodstuff put into the machine at one time for drying. The drying time (period) depends on the type of foodstuff and the intensity or availability of sunlight and also on the thickness of the slice of foodstuff. Generally, however, with good sunlight the average drying times are as indicated in Table 5:

<table>
<thead>
<tr>
<th>Food type</th>
<th>Average Drying Period (Days)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fruits</td>
<td>3</td>
<td>5mm slice size</td>
</tr>
<tr>
<td>Vegetables (leafy)</td>
<td>1 to 2</td>
<td></td>
</tr>
<tr>
<td>Fish and Meat</td>
<td>7</td>
<td>Fish cut in traditional/common way, i.e. cut open in length</td>
</tr>
</tbody>
</table>

In Zambia, generally the periods with good sunlight for the better performance of the solar-powered drying machine is from April to early December. Thus generally, the rainy season does not give good sunlight for drying.

The maintenance costs of the machine are minimal, in general, because the machine is largely made of metal and so durable (not many delicate and moving parts). The green house plastic normally lasts up to three (3) years. The machine can be used to dry own crops (crops of beneficiaries/owners) and also of other people at a fee to generate income. The income generated from drying other people’s crops can be used for various other beneficiary needs as well as being used for meeting the required maintenance costs and may as well be saved and used for machine replacement (in case of complete breakdown) or for buying additional machines to increase the number of machines so as to expand/scale-up the business. However, under the EWAS Project, the beneficiaries in Gwembe and Senanga Districts do not utilize the income generated from the drying machine for repair or maintenance, neither do they save with the aim of either replacing the machine or procurement of additional dryers. The Project on the other hand carries out all the repair and maintenance works on behalf of the beneficiaries; this is seen as not encouraging or promoting a sense of ownership of the machine by the beneficiaries. The innovation is environmentally friendly as it uses solar energy for its operation. However, prolonged periods (days) of cloud cover or rains may enable the machine not to function or slows down its effectiveness.

The machine is locally made (within the Country) and by a Zambian and thus there are little or no administrative and logistical bottlenecks in its acquisition as compared to imported items. The machine is fabricated at a plant in parts, in Lusaka and then transported in parts for assembling at the place where it is to be installed. Therefore, once installed at a particular permanent place,
it is then immovable. It requires adequate space (ground area) where to be placed, depending on the size of the drying machine; and since the machine uses solar power, the area/place has to be free from sunlight obstruction, i.e. requires an open place.

Its placement or installation in an open (outside) place necessitates protection or security, particularly from physical damage or theft of some parts. Although, the place is normally fenced (with wire, grass or wooden fence, as is the case in Gwembe and Senanga Districts) for protection, there is need for enhanced protection and/or even guarding. The particular critical parts which require protection are solar panels, which could be stolen and the plastic covering which could be damaged, especially by children (pricking into it) or animals, e.g. dogs and cattle, biting or treading on it (see pictures below).

**Left & Right: Solar-powered drying machine with damaged plastic covering**

The cost of procurement of the machine (see Table 4) is rather on the high side, for most rural poor Zambians. The machine is said/reported initially to have had a weakness with regard to the durability of the fan. Initially the fan blades were made of hard plastic material and thus the blades used to break frequently. However, this problem has now been sorted out by the change of the materials used to make the fan blades; now the blades are made from metal and thus are more durable. The plastic covering was also reported as not being very durable, over time, even without animal or human damage. In order to minimize the maintenance costs, particularly in terms of transportation of the broken-down machines for repair by the manufacturer or designer based in Lusaka, the Project is currently working with the manufacturer to train Small & Medium Scale (SMEs) fabricators located within the Project areas, in undertaking repair works (at least minor repairs) locally in Senanga and Gwembe Districts.

However, since currently the machines in use are given to the Project beneficiaries freely, the sustainability of the innovation may not be guaranteed when the Project comes to an end. It is hoped that the beneficiaries will have made enough savings to be able to buy other machines on
their own (although as reported above this is not the case under the EWAS Project; the Project bears all the repair and maintenance costs). Additionally, there is low effective demand for the dried products, particularly within the EWAS Project areas (because of high poverty levels among the local communities) and thus not much income is generated from the innovation to afford the repair, maintenance and replacement costs of the machine.

4. **Economic Feasibility /Benefits:**
The innovation has shown both economic and social benefits. The economic benefits come from the income generated from the sales of the dried crops (see some pictures below) as well as from the user-fees charged to other people for drying service provision. The EWAS Project implementer (PAM) indicated that an average of K600.00 (Zambian Kwacha Six Hundred Only) is generated per month (i.e. about US$ 60 per month, at the current exchange rate); however, PAM reported that the generated income ranges from K600 to K1,000 per month. On the other hand, one women club, particularly Mubombo Women Club, in Gwembe District reported that it charges K3 per tray for drying foodstuffs of non-members; this would be far less than the PAM's above reported average income generated per month, considering that not more than four trays could be or is dried per day by the Club for non-members.

![Left: Dried bananas and mangoes. Right: Dried bananas, and Dried and processed mangoes](image-url)
Left & Right: *Displayed dried mangoes, including some poorly dried or burnt ones*

Packaged dried mangoes

Left & Right: Different types of dried vegetables
Maintenance costs of the machine are also said to be minimal and thus affordable (maintenance costs can be met from the income generated). Most parts of the machine are made of metal and therefore more durable. The part reported to be not so durable is the greenhouse plastic covering, which may require relatively frequent replacement compared to other parts. Nevertheless, if not broken either by animals or children the plastic may normally last for more than a year and thus may not cost so much with regard to frequency of replacement.

Although not much income is being generated by the EWAS Project beneficiaries from the innovation, some households are able to afford to pay school fees for their children, at least for nursery schools. On the other hand, some beneficiaries (e.g. Tusole Kuyusa Women Club of Gwembe District) currently are not even charging anything for drying other people’s (non-members’) foodstuffs: thus no income is generated at all from the innovation (advanced reason for not charging is that they want to create interest and also promote awareness in non-beneficiaries).

Apparently, there appears to be more social benefits than economic benefits being derived from the innovation, particularly in terms of food and nutrition security. Various foodstuffs such as fruits, vegetables and mushroom could be dried and therefore preserved for consumption for even more than seven months (even highly perishable and seasonal foods may therefore be available throughout the year). Therefore, this is a major benefit especially for drought and poverty stricken areas such as Gwembe. Additionally the dried food stuffs are of high quality (not exposed to dust and pets damage); convenience of drying with no disruption from rains and throughout the year and at any time of the day. Other social benefits accrued from the innovation include labour and time saving by women: while drying using the machine the women can be engaged in other household activities.

5. **Scalability:**
The solar-powered drying machine can be used in any parts of Zambia as there is adequate, if not abundant sunlight in all parts of the Country.
In this second phase of the EWAS Project, there are plans to extend the same innovation to four (4) other districts within the current operating Provinces, that is, to Pemba and Sinazongwe Districts (Southern Province) and Kaoma and Nalolo Districts (Western Province).

However, once the Project comes to an end there may be challenges of scaling up the innovation due to the initial cost of the machine and that the machine can only be procured from Lusaka, which may be distant from other needy areas (particularly rural areas). Although the machine is locally made, its price may limit scaling up especially among the majority rural poor people of the Country. The high cost of the drying machine is largely due to the (metallic) parts used in its fabrication which are imported, even though they are bought locally. The fans on the other hand are directly imported from either China or USA.

c. Name of Innovation: “Use of Energy-saving Stove for Cooking (impact in Gwembe & Senanga Districts)”

1. Background:
The innovation of the promotion and use of energy-saving stove for cooking was initiated in consideration of the much time, particularly women were taking in fetching for firewood in the bush for cooking and their energy dispensed in carrying the ‘heavy’ firewood. The innovation was also triggered by the policy to curb de-forestation, brought about by the cutting of big trees for fuel (charcoal and firewood). This is thus a time and labour-saving, as well as an environmental protection innovation.

The Program Against Malnutrition (PAM) therefore started a Project targeting women groups in Senanga and Gwembe districts. The two Districts are adversely affected by climate change resulting in high poverty levels. In searching for firewood and also cutting of trees to make charcoal for cooking, women were walking long distances, taking so much time and employing so much labour and energy in collecting, carrying and producing firewood and/or charcoal. With so many trees being cut for both firewood and charcoal, much areas were/are rendered prone to deforestation, exacerbating climate change, especially that these Districts do not even receive enough rainfall (being located in the Country’s poor rainfall agro-ecological regions).

The target women are therefore trained in making energy-saving stoves, locally within their Districts and/or villages, using clay soil. These stoves use twigs instead of firewood or charcoal.

Between the two selected project districts, there are more stoves (Project more successful) in Senanga District because of the availability of the suitable soil type, nearby the localities of the Project beneficiaries.

In minimizing de-forestation, the women are encouraged to grow/plant trees, specifically, Moringa and Gliricidia sepium. The planting of these trees is promoted by PAM in partnership with the Conservation Farming Unit (CFU).

The livelihood of women in these districts has thus improved because the innovation has reduced the time and energy it takes them in search of firewood in the bush and ferrying it to their homesteads. Consequently, the women have more time and energy to engage in other
household activities and even other economically productive ventures. Deforestation is also being minimized.

2. **Projected pathway to generation of solution:**
   There are other various ways of saving women’s time, energy/labour and protecting trees (minimizing deforestation) for the purpose of cooking, particularly in rural areas, such as using electric stoves and gas stoves. However, the use of the energy-saving stove appears to be the logical pathway to the solution.

   The use of this energy-saving stove has the following advantages:
   
   ▪ The materials (clay soil) to use in making the stove is locally available and normally at no cost;
   ▪ The twigs to be used in the stove for cooking are readily and abundantly available (and mostly within proximity of homesteads) and normally at no cost; and twigs from any tree can be used.
   ▪ Twigs are very light to carry; even children are able to carry;
   ▪ Cooking continues even when twigs are finished on the stove because the stove itself retains the heat for some time;
   ▪ Electricity and gas is not available and/or not easily accessible in most rural areas of Zambia; and where available it is not cheap to be afforded by most rural women (most of which are poor);
   ▪ Both electric and gas stoves are relatively expensive, and not readily affordable by most rural poor communities. Moreover, they are not readily stocked in rural areas;
   ▪ To most rural and poor women, including children, both electricity and gas can be or is a serious fire hazard.

   However, the use of twigs for cooking (like firewood) produces smoke when burning which may result in choking and may also be a health problem to the users (through inevitable inhaling), especially when exposed to it for long periods (years). Although lighter and easily available, larger quantities of twigs may be required/used compared to firewood, charcoal, electricity and gas, to cook the same amount of food; twigs burn and finish faster (because of their smallness in size) as compared to firewood and charcoal.

3. **Innovation Description:**
   The use of an energy-saving stove is a technical innovation for domestic cooking using a stove (like a brazier) made from clay soil (although others mix the clay soil with cow dung and sand, e.g. in Senanga). The design of this stove has been developed and being promoted by Zambia Energy and Environmental Organisation (ZENGO) in collaboration with the Government’s Department of Energy. PAM introduced the energy-saving stove to its EWAS Project beneficiaries, in partnership with ZENGO (who makes the stoves and supplies them to PAM) and through the same partnership, ZENGO trains PAM’s project beneficiaries in the making of the stoves (also locally called “Pulumusa”, meaning “Saviour”). This stove uses twigs instead of charcoal or firewood. The process of cooking with this stove is just like that of an ordinary/usual charcoal brazier or electric and gas stove, where foodstuffs are cooked or fried
and/or water is boiled, whichever is the case, in a pot, pan or dish put on top of the stove. The twigs are put/inserted into the energy-saving stove through a hole below the pot/pan. The twigs are lit with fire and burn to produce the heat for cooking or frying: more twigs are put into the stove until the food is cooked/fried or water is boiled. The stove accommodates only one cooking utensil (pots/pan/dish) at a time and thus if more foodstuffs need to be cooked/fried/boiled at the same time, it would require using more than one stove. The clay (main material for making the stove) also gets heated thus the stove retains heat for some time for continued or longer cooking even after twigs are finished.

Left: Energy-saving Stove. Right: cooking on the energy-saving stove

Energy-saving stove with twigs for cooking

The making of the energy-saving stove requires a certain type of clay. In some areas, like Senanga, clay soil is also mixed with sand and cow dung (fresh or dry; however dry cow dung is preferable).
For durability a certain proportion of each material in the mixture is required in making the stove as well as skill (more sand weakens the stove; similarly poor workmanship, i.e. if the different parts are not properly joined and the stove is not well dried, e.g. not dried in a kiln; merely sun-dried stoves are also not durable [see some photos below]). It takes about one day for the stove to be molded and then left to dry: however, it takes approximately three weeks from molding/making for the stove to be ready for use.

Left & right: Some poorly made energy-saving stoves (broken)

Left: Kiln for drying the stoves. Middle & right: Inside of the drying kiln

Nevertheless, it was reported that even properly made stoves normally lasts for about three months: with better quality clay, the stove may last for about five months. Besides improper making materials (i.e. poor quality clay, where a mixture of materials is used, improper mixture of clay, sand and cow dung) and poor workmanship (i.e. unskilled manpower), durability of the
stoves is also dependent on how the cooking is done (i.e. the pressure applied when cooking) and frequency of use: since the stoves retain heat even after the twigs are finished, the more the stove is used and how the cooking is done contribute to breakage of the stoves. For example, more exertion of pressure when cooking nshima and the larger the size or weight of the cooking utensil and foodstuff contribute to easy breaking of the stove. And apparently, once broken the stoves are not or cannot be mended.

In some places, however, good quality clay required for making (durable) stoves is not or may not be found nearby and generally clay is heavy to carry, thus arduous. This therefore discourages some people, particularly women. For example in both the EWAS Project operating districts (Gwembe and Senanga), it was reported that good quality clay is found in distant areas e.g. Sinafara area which is about 60Km from Gwembe Boma, thus transport costs have to be incurred. In Senanga District, good quality clay is found in the Zambezi River plains, which usually get flooded during the rainy seasons.

The short life-span of the stove (even of good quality) due to breaking could also be a drudgery or constraint to the adoption, practice or scaling up/out of the innovation.

4. Economic Feasibility /Benefits:
The innovation has been economically beneficial although more benefits have been social and environmental. Monetary benefits have come through the sales of extra made stoves. ZENGO has been assisting Project beneficiaries by either buying or finding buyers for extra stoves. However the demand for buying from the local communities within the EWAS Project operating areas is low, since the local non-member communities are also trained to make their own stoves. Some Project beneficiaries, however, indicated that if they were to sell the stoves to other people within their districts, they could be selling at K20 and K15 each for the good and poor quality stoves, respectively: willingness to explore this opportunity in future was expressed. The Tukonkote Lichecha Group (one of the EWAS Project beneficiaries) of Senanga District in Western Province reported that ZENGO was buying or offered to buy extra energy-saving stones at K40 per stove.

The innovation has proved more beneficial socially and environmentally. Some of these benefits include:

- Time and energy/labour-saving (especially for women): Women are saving or have saved on the time and energy and/or labour they had been spending in walking long distances fetching and carrying heavy firewood and charcoal for cooking. The saved time is now utilized in carrying out other household and income-generating activities. The men who are usually the ones engaged in charcoal burning have similarly found time and energy relief in the innovation. Children have equally benefited on time to socialize and utilize for school work/programmes: some children used to be sent to also look for or buy firewood and/or charcoal by parents (to assist parents).
- The twigs used in the innovation are normally found within the homesteads (twigs from any tree can be used) and are light to carry and are normally at no cost. Thus even children are able to collect and carry the twigs.
- The stove is easy to make by both male and female. Beneficiaries are trained or taught how to make the stoves.
- The material (clay soil) for making the energy-saving stove is locally available (within the Districts) and easy to find and collected at no cost (not bought). However, as mentioned under Section 4 above (Innovation Description), in some places good quality clay may not be found in nearby places and is also heavy to carry.
- Energy-saving stove cooks faster compared to charcoal braziers or firewood; and compared specifically to using firewood, energy-saving stove produces little or no smoke thus food cooked is of better quality (no smoke-smell); also the people cooking do not get choked by smoke.
- Cooking/frying of food or boiling continues (for some time) even when the twigs are finished on the stove because the clay stove retains heat.
- De-forestation has been/is minimized, thus also minimizing on the severity and frequency of climate change effects (few tress are cut).

The locally trained people also train or are expected to train other people within their communities in how to make energy-saving stoves. The Tukonkote Lichecha Group (under the EWAS Project) in Senanga District, for example, not only train other interested non-members within their community but also freely give them some already made stoves (although normally gives out the poor quality stoves).

5. Scalability:
The innovation has high potential for scaling up and scaling out since the stove is easy to make, by both female and male, and at no monetary cost. The clay soils (major materials) used to make the stove are available in most places and normally collected free. Additionally the cooking materials (twigs) are found almost everywhere and mostly near homesteads, especially in rural areas; and generally twigs from any tree can be used for cooking. The twigs are light in weight and thus can easily be carried by people in reasonably large quantities, even by children; transportation by various modes is also easy.

Additionally, the labour/energy and time saved both in looking for and collecting/carrying firewood or charcoal, when using the energy-saving stove is an indicator for high potential for scaling up and out of the innovation, especially as appreciated by the women (users).

However, scaling up and out of the innovation may be challenging in some areas where the required type of clay for making the stove is not/may not be available in nearby places or may not be available at all. Also, where other additional materials e.g. cow dung and sand are not available or are/could be found in distant places.

With regard to its rather short usable time (2-5 months), there are suggestions to add other materials such as cement in order to increase its durability. However, it is not yet known whether
this might not compromise the stove’s heat retention properties. If this could improve durability and not negatively affect the heating properties, there may be issues of the cost and availability of cement or other materials that may be suitable, to consider for other areas and intended beneficiaries. Therefore, there is need for further research into the issues of extending the stove’s usable period without compromising its heating properties or better still improving/increasing its effectiveness at the same time.

Also, in areas where the initially trained people are not willing or able to train other people, for various reasons, as found out in Gwembe District, scaling up or out of the innovation may be limited.

D. Name of Innovation: “Production and use of High quality Cassava Flour”

1. Background:
Cassava is the most important crop grown and being commercialized in Zambia, after maize. However, cassava is largely grown in Luapula, Muchinga and Northern Provinces of the Country, predominantly by small scale farmers (by about 35.5% of small scale farmers in Luapula and by about 32% in Muchinga and Northern, combined). Other smaller cassava growing areas include North-western and Western Provinces. In some regions within these major Cassava growing areas, more than 80% of farmer household populations depend on Cassava for food security and/or incomes.

For more than a decade now, the Zambian Government, including national and international donor development organisations have been developing policies and exploring opportunities to encourage cassava production and the development of agro-industries to add value to the crop with the aim of developing the cassava sector in order to increase food security and increase rural income. This is especially so with the prevalent unfavorable climatic conditions as a result of climate change.

Cassava has high potential not only to ensure household food security but also to contribute to the Country’s economy through employment creation for Zambian people (in industries), local and export revenues, if its full commercial potential is exploited; thus contributing to overall social and economic development of the country.

With this policy objective, the Government launched the private sector-led Cassava National Strategy for Zambia in December 2009. The Cassava strategy prioritizes domestic markets particularly with regard to the existing processing potential for flour (including livestock feeds) and for substitution of imported starches.

Traditionally, cassava in Zambia has been and is still associated with subsistence fragmented production and with rural poor households. Therefore, the change or need to emphasize the promotion of value-addition triggered the generation of the innovation to “produce and use of High-Quality Cassava Flour”. Another issue which led to the generation of the innovation is that in the major cassava producing areas, the crop is largely consumed after it is fermented (traditionally soaked in water for some days, after which it is consumed in various forms, e.g. as
mealie meal for nshima, roasted, cooked etc.), but other people (mostly from non-cassava producing areas) do not like consuming cassava in fermented form due to the resulting flavour “smell”. Also, when used for confectionery/baking cassava flour does not need to be fermented. There is no fermentation requirement for producing High Quality Cassava Flour (HQCF) and so there is no apparent detestable flavour or smell but tastes good. However, if using the bitter cassava varieties, fermentation is inevitable in order to remove the inherent bitterness caused by hydrogen cyanide (which could even be poisonous if consumed in large quantities). Therefore, in the production of HQCF sweet cassava varieties (which have low hydrogen cyanide) are used, which can directly be dried, without fermentation, e.g. the local Mweru and Kampolombo varieties. Additionally, HQCF is produced from cassava varieties having high starch content such as Mweru and Chila. But most of the local cassava varieties have low starch content. Since maize is Zambia’s staple food crop, the implication of the situation before the innovation was that most Zambian’s depended or would have depended on maize mealie meal for starch.

2. **Projected pathway to generation of solution:**

Zambia’s agriculture has predominantly been monoculture, largely depending on the production and consumption of maize, being the staple food, for food and nutrition security, as well as for income, especially in rural areas. This is notwithstanding the fact the Country has a wide variety of food crops. Thus, the Government has been promoting and advocating for agricultural and food diversification, both in production and consumption, including value-addition, as a pathway to sustainable opportunities to increase food security and rural income generation.

The production and utilisation of High-Quality Cassava Flour has therefore been one of the pathways in achieving the above objective. Comparing maize, wheat and cassava flour, with regard to addressing food security and income generation, including employment creation, especially among the Country’s rural poor, the production and utilization of HQCF appears to be relatively the most logical pathway to the solution, due to some of the following advantages:

- **Cassava is a low input crop and able to grow quite well even under low management; thus, being predominantly grown by small scale farmers in Zambia;**
- **Cassava is able to withstand the prevalent climatic change effects. Additionally, it is largely grown in the Country’s high rainfall area (Agro-ecological Region III); not very prone to droughts;**
- **HQCF has relatively more multiple uses, such as: useful in the wood and paper mills/industries (as source of glue); can be blended with maize mealie meal for nshima preparation; and can be blended with wheat flour for bread-making (10% of cassava flour to wheat flour cannot easily be differentiated in bread taste. Besides being mixed with either maize or wheat flours, it can also be used alone in the making of these products (nshima, bread, fritters, starch and other confectionery uses);**
- **HQCF therefore has high demand potential by millers, bakeries and the wood & paper industries.**
- Cassava is not as seasonal a crop as maize and wheat (with regard to production), even without irrigation, and upon maturity, it can be harvested anytime from the field and processed and/or consumed directly; thus, does not pose serious storage challenges;
- Like maize, cassava is also a staple food for at least 30% of the Zambian population and more than 80% of the farmer households in the Country’s major cassava regions, depend on cassava for food security;
- Cassava can be and is normally intercropped with maize and beans.

However, production of HQCF requires sweet varieties (which do not need fermentation when processing) and high starch content varieties, e.g. Mweru and Chila varieties. These genetic characteristic requirements may pose tradeoff challenges, if suitable varieties are not available.

3. **Innovation Description:**

The production of HQCF is a technical innovation. Harvested cassava tubers from the field are brought to the plant where pealing and washing is done (normally by women). The cassava tubers are then put into the crating machine where they are cut into smaller pieces (chips). Thereafter cassava chips are fed into the feeder of cassava drying machine. In the feeder the chips are squeezed, crushed and dried and then removed and put into the grinding mill to produce the high-quality cassava flour.

The varieties used (preferred) to produce the better-quality flour are the sweet varieties and with high starch content, such as the Mweru and Chila varieties. The sweet varieties do not need to be soaked into water before drying and grinding and thus with these varieties the process takes 2-3 days. On the other hand, if the bitter cassava varieties (most local varieties) are used, the process takes longer as the harvested tubers from the field, after peeling, have to be soaked in water for 7 days and then dried for one to two days before milling into flour.

This process is socially accepted and environmentally friendly because it does not pollute the environment.

The process of producing HQCF using a milling plant/equipment is easy, involves few workers and both males and females are involved.

Below are some photos of the High-Quality Processing Plant (PECO’s Plant in Mansa District of Luapula Province)
Constraints to the practice of the innovation may include:

- Involves some labourious activities e.g. harvesting (digging) of cassava tubers, pealing, washing and loading/putting into feeders;
- In case of bitter varieties, soaking in water for about 5-7 days, before processing, thus time consuming;
- High investment cost of milling/processing plant (e.g. PECO bought the machinery from Nigeria at US$30, 000);
Sometimes there may be challenges to get enough cassava tubers and suitable varieties (high starch content and/or sweet varieties) to sustain the production of High Quality Cassava Flour, due to low cassava productivity and production by the cassava farmers and high purchasing price of cassava (sometimes cassava prices are increased due to high demand or unfavourable competition among buyers, particularly when there is no supply contract with farmers).

4. **Economic Feasibility /Benefits:**
HQCF can be or is used on its own or mixed with wheat flour in baking and/or confectionery industries for making bread, cakes, scones, biscuits etc. and is rather more economical compared to using only wheat flour. It can also be used in the wood and paper industry. The Zambian wood and paper industry demand more than 300 metric tons per month, although more of starch is needed than flour. There is fairly good demand in the Country for starch and cassava flour in the range of 30%-40%. Cassava flour may also be utilized for beer brewing and livestock feed production, although currently some Zambian brewing and livestock feed manufacturing companies are not sure of what is better to use between flour and chips.
HQCF contributes to food and nutrition security as well as income generation. Availability of this type of flour is more reliable compared to wheat flour in that cassava is a cheaper input cost commodity and is not affected very much by climate change.

5. **Scalability:**
The potential for scaling up the innovation is high in that cassava is widely and easily grown by small scale farmers. With the crop’s ability to withstand climate change effects, it can be produced throughout the Country; thus there is an increasing number of farmers growing cassava and the specifically required cassava varieties (e.g. Mweru and Chila) for the production of HQCF are readily available. There is good and growing domestic and industrial demand for the commodity. However, the current low cassava productivity and production in the Country would slow down scaling up of the innovation coupled with the increasing price of cassava demanded by the cassava farmers. In fact, some processing plants, such as PECO in Mansa District, stopped producing HQCF due to insufficient cassava to run the plant and the high price of cassava.
Low cassava productivity, production and quality can be addressed if farmers are engaged/contracted or organized in out-grower schemes, through which even other services such as extension and inputs can be provided.
The high investment cost of the HQCF processing plant/equipment is also a drawback to the scaling up of the innovation. This is especially so with the prevailing high interest rates of borrowing.
E. Name of Innovation: “Production and Supply of Disease-free Cassava Planting Materials”

2. Background:
Cassava is the most important crop grown and being commercialized in Zambia, after maize, due to its high potential to contribute to household and national food security, household income generation, the Country’s economy through employment creation for Zambian people (in industries) and revenues. Particularly, in the Country’s major Cassava growing areas (Luapula, Muchinga and Northern Provinces) more than 80% of small scale farmer household populations depend on Cassava for food security and/or incomes. Additionally, cassava contributes 38 percent of Zambia’s total human consumption requirements and is a staple food for at least 30% of the Zambian population. It is known and identified by various local stakeholders that more than 200 processed products can be derived from cassava roots and leaves and that there is significant local and international market potential for these products. Thus for more than a decade now, the Zambian Government, including national and international cooperating partner organisations have been developing policies and exploring opportunities to promote and increase cassava productivity and production and to develop agro-industries to add value to the crop with the aim of developing the cassava sector in order to increase food security and increase rural income. One of these Government and stakeholder efforts culminated in the development and launch of the Cassava National Strategy for Zambia, on 11th December 2009. The vision for the Cassava National Strategy for Zambia was/is “A viable cassava industry contributing to wealth creation and food security for improved livelihoods by 2015”.

In Zambia cassava has been grown for several decades predominantly by small scale farmers. However, its increased productivity and production has been hampered by the occurrence, prevalence and spreading of diseases and pests through the producers’ continued use of infected and infested planting materials. The most common and prevalent diseases are the Cassava Mosaic Virus and the Bacterial Blight diseases. These diseases can reduce cassava yield from 40MT/ha to as low as 5MT/ha and also reduces the quality.

With the above yield reductions and taking the current farmers’ selling prices of cassava tubers and cuttings at K25 per 100 cuttings and K56/40kg of tubers, farmers would lose K49,000 (US$4,900) per hectare (i.e. yield loss per hectare: 40MT– 5MT = 35MT=35,000Kg. Income loss: 35,000Kg/40Kg X K56=K49,000).

Therefore, as a consequence of the incidence and prevalence of these diseases, the Country does/would not have adequate cassava to meet the required volumes/quantities, quality and consistent supplies for household and industrial needs, including export demands; and thus also contributing to food insecurity and loss or reduced household incomes and national revenues.
Other consequences of the reduced productivity and production due to disease occurrences and prevalence is or would be reduced or non-existence of investment in the cassava sub-sector. In addressing the above negative effects, the Government’s research wing (ZARI) embarked on the production and supply of disease-free cassava planting materials, in order to mitigate the effects of Cassava Mosaic Virus and Cassava Bacterial Blight diseases.

3. **Projected pathway to generation of solution:**
   The various ways of controlling or mitigating reduced productivity, production and quality of cassava and avoid or minimize the associated household and national income losses and also ensure/maintain household and national cassava food security, due to occurrence and prevalence of diseases include:
   - Conventional disease control;
   - Breeding disease-free planting materials.

**Conventional Disease Control:** This pathway largely involves the use of various synthetic and organic chemicals to control Cassava Mosaic Virus and Cassava Bacterial Blight diseases (chemical disease control). This methodology requires much care/caution in its use because some or most of these chemicals are dangerous or potentially dangerous if not properly used/handled during application and/or in storage. Most of these chemicals are or may also be expensive and thus may not be afforded by most cassava growers, in the Zambian case, the small scale rural farmers. Additionally, some of the chemicals have or may have side effects to either the users (human beings) or the environment; or to both.

Additionally, the required chemicals may not be available (stocked) within the proximity of cassava growers, as is largely the case in most rural areas where small scale cassava growers live; thus accessibility may be a challenge even when funds are available for procurement of the chemicals.

**Breeding Disease-free Planting Materials:** this method involves research in breeding cassava varieties which are resistant or tolerant to common and prevalence diseases, in this case, which are resistant or tolerant to Cassava Mosaic Virus and Cassava Bacterial Blight diseases. These bred varieties are then multiplied and the planting materials (cuttings) from the disease resistant or tolerant varieties are supplied/sold to farmers to plant.

The production and use of disease-free cassava planting materials is the most logical pathway to the solution. The cuttings are relatively cheaper compared to disease control chemicals and do not require specialized handling in their use (normal agronomical practices which are generally known by farmers are involved) and thus the innovation is socially accepted by farmers who have adopted and easy to practice by both gender. The cassava varieties from which the cuttings are obtained are normally also bred for other improved characteristics e.g. high yielding and drought tolerance. Although the breeding method is/ could be lengthy, the pathway is cheaper/economical in the long-run. The breeding method is environmentally friendly.
However, this pathway also has some challenges which necessitates some tradeoff. Some of the challenges include:

- Requires specialized human resources (Breeders);
- Cuttings though light but are or may be bulky, depending on the area size of the field to be planted and thus carrying/transportation may be challenging.
- Mode and cost of transportation of the cuttings may also be a challenge when needed for planting in areas/places far from the sources of the disease-free varieties.

4. **Innovation Description:**

The innovation is technical as it involves scientific breeding for disease-free or tolerant cassava varieties. The method aims at preventing the disease vector from transmitting the virus/bacteria causing the disease from establishing on the plants. It works through the generation or breeding of disease-resistant genes in cassava varieties. The resistance genes do not allow cells to be colonized by the virus/bacteria causing the disease.

The process involves identification of clones which are not affected by the disease. These are then crossed with the susceptible varieties and symptom-free progenies are selected. The disease symptom-free progenies are propagated in tissue culture to generate disease-free plants which are then multiplied in the field. The multiplied disease-free plants are then distributed from which the planting cuttings are taken.

The innovation enhances the quality of the planting material. The innovation is sustainable as the bred varieties/planting materials carry the genes for resistance, which do not allow cells to be colonized by the virus causing the disease. It is socially accepted by farmers (have adopted the growing of disease-free planting materials) since the innovation has resulted in the replacement of diseased cassava varieties that were low-yielding. This innovation has no negative effect on the environment.

The research process takes 7 to 8 years to come up with disease-free cassava varieties from which to get planting materials (needing about 1,000 man days and US$ 400,000 in terms of variable costs).

The innovation, however, has some constraints such as the need to have laboratory facilities for long term storage of disease-free materials, which are or could be costly; also the process is/may be long and costly. The innovation is not so easy to practice because it requires some professional technical knowhow (breeding expertise). Additionally, laboratory work requires at least two persons working in the laboratory at one time.
5. Economic Feasibility /Benefits:
This innovation is economical especially to the small-scale cassava farmers as it increases their yields and quality of cassava, by the reducing the most common cassava diseases; thus increasing their income through more high quality cassava sales. It also saves them money on the cost of chemicals they would have to incur in order to control the cassava diseases, if they had to plant non-disease-free cassava plants/varieties. Additionally, it enhances the food security of most of the small scale and rural households who depend on cassava for their livelihood.

Cassava farmers would have their own disease-free cassava cuttings to multiply on their farms and so enjoying easy access to planting materials and to supply to other farmers within their localities. The sales of these disease-free cuttings would earn the farmers income. For example the farmer’s yield increases from say 5MT/Ha to 40MT/ha through the use of these disease-free cuttings (under good management), as compared to the use the disease-prone varieties: with the selling price of K56 per 40kg, the farmer will earn K49,000/ha (the average yield of the local cassava varieties which are prone to diseases is 5MT/ha). There would also be extra income coming from the selling of disease-free cuttings as planting materials to other fellow farmers (cuttings are currently being sold at K25 per 100 cuttings).

The use of disease-free cassava planting materials also contributes to the Country’s achievement of its agricultural diversification goals and commercialisation strategy of cassava. Increased supply of high-quality cassava promotes the development of various processing industries in which cassava and cassava products are the needed raw materials, such as the milling industry, livestock industry, wood and paper industry as well as the bakery industry. Increased industry production and output generates employment for Zambians and revenue to the Government.

6. Scalability:
The innovation has relatively good potential for scaling up because once the breeding of disease-free cassava varieties is complete the planting materials can easily be multiplied throughout the
Country by selected farmers in their own fields, by creating as multiplication plots. However, the technology requires setting up cassava multiplication plots in areas with low disease pressure, which would serve as sources of planting materials for cassava growers in the long term. These cassava multiplication plots would reduce the cost of accessing the seed/planting materials. On the other hand scaling up and out could be a challenge as the technology requires some huge investment in terms of laboratories equipped with the necessary facilities at research stations: also the requirement to link screen houses to laboratories and multiplication fields. The establishment of fields in low-disease pressure areas entails incurring transport costs for moving planting materials to these new sites.

F. Name of Innovation: “Production and Promotion of Yellow-fleshed Cassava”

1. Background:
Refer also to the innovation on “Promotion of Pro-vitamin A (Orange) Maize for Improved Nutrition”, i.e. Innovation A.
Just like the promotion of Vitamin A Orange maize, the innovation to produce and promote utilization of yellow-fleshed cassava was/is a result of the policy to address vitamin A deficiency in the Zambia population, with high cases among children under 5 years of age.
Vitamin A deficiency has a number of serious health problems including stunting in children, blindness and limited cognitive abilities. Therefore, in addressing such health or nutritional challenges, under the broader umbrella of enhancing nutrition security, the research in the production and promotion of yellow- or orange-fleshed cassava aims at widening the biological sources of vitamin A.
Recognizing the benefits of bio-fortification in the provision of Vitamin A, the Government through the Ministry of Agriculture’s Zambia Agriculture Research Institute (ZARI) embarked on researching on the production of yellow-fleshed cassava, as a promising technology for becoming an innovation. In the 2016-2017 agricultural season, the research trials have now moved on to field trials.

2. Projected pathway to generation of solution:
As already noted under the innovation for promoting production and consumption of Pro-vitamin A Maize (Orange maize), a number of efforts are in place for combating Vitamin A deficiency in Zambia such as:

- Educating or teaching the Zambian population on the importance of having a balanced diet, with emphasis on adequate consumption of foodstuffs containing vitamin A;
- Fortification of processed cane sugar;
- Production and consumption of orange maize (Pro-vitamin A maize);
- Administration of “high” dosage of Vitamin A;
- Breeding and production of orange-fleshed sweet potatoes; and
- Breeding and production of yellow-fleshed cassava roots.
3.1 Teaching on the importance of having a balanced diet, with emphasis on adequate consumption of foodstuffs containing vitamin A: this is normally undertaken through health education to the public, especially to mothers and children, in various public and private health and education institutions (clinics, hospitals, schools etc.). Sometimes such education is provided to the general public through various open awareness functions conducted in various places any time, usually by the Ministry of Health.

3.2 Fortification of processed Cane Sugar: through the Government’s Statutory Instrument No. 155 of 1998 (SI 155), all cane sugar produced for sale in Zambia for human consumption is by law supposed to be fortified with Vitamin A. Thus, the utilization of cane sugar is another way of addressing Vitamin A deficiency in Zambia as all the cane sugar produced and sold in the Country is fortified with Vitamin A. Zambia Sugar Company, as the major cane sugar producing company in Zambia, started the sugar fortification process.

3.3 Production and consumption of orange maize (Pro-vitamin A maize): ZARI in collaboration with HarvestPlus has since 2013 been releasing Orange maize (Pro-Vitamin A) seed varieties which contain Vitamin A. These seed varieties have been released, registered with SCCI and licensed to various private seed companies for commercialisation and selling to the public (farmers).

3.4 Administration of “high” dosage of Vitamin A: People diagnosed with Vitamin A deficiency are given Vitamin A medicines (tablets or capsules) at various public and private health institutions, including pharmacies throughout the Country. Particularly, children under five years of age, pregnant women and lactating mothers are normally checked/tested for Vitamin A deficiency at clinics and hospitals as they attend under-five, pre-and post-natal clinic sessions (these of the population categories are the most vulnerable to vitamin A deficiency according to empirical evidence).

3.5 Breeding and production of orange-fleshed sweet potatoes: As it has scientifically been known, most orange- and/or yellow-fleshed foodstuffs contain vitamin A; consequently, from the early 2000s, ZARI has been breeding orange-fleshed sweet potatoes as one of the pathways for addressing vitamin A deficiency. So far six (6) varieties of orange-fleshed sweet potatoes have been released by ZARI, i.e. 2 in 2003 and 4 in 2015. However, as compared to maize and cassava, sweet potatoes are not generally grown in all or most parts of the Country and are rather seasonal, not a staple food crop and thus they are less available and not consumed widely. Therefore orange-fleshed sweet potatoes are or may be not as effective as orange maize and yellow-fleshed cassava as a pathway in alleviating vitamin A deficiency in Zambia.
3.6 *Breeding and production of yellow-fleshed cassava*: ZARI embarked on the research for the production and distribution of yellow-fleshed cassava in contributing to addressing Vitamin A deficiency in the Country, which is high especially among the under-five children and lactating mothers. The innovation widely also contributes to enhancing household and national nutrition security.

Cassava being the second most important crop grown in Zambia, after maize and being commercialized, especially with the development of the National Cassava Strategy for Zambia (in 2009) due to its high potential to contribute to household and national food security, household income generation, has high potential to contribute to the alleviation of Vitamin A deficiency in the Country.

Looking at the pros and cons of Vitamin A fortification, particularly from the Government’s perspective, as shown below in Table 5, bio-fortification is the most logical pathway to addressing the problem of Vitamin A deficiency in Zambia. And the innovation of the “Production and Promotion of Yellow-fleshed Cassava” is or would be the second-best most logical pathway to the solution, after the “Production and consumption of orange maize (Pro-vitamin A maize)“.
<table>
<thead>
<tr>
<th>S/N</th>
<th>Vitamin A Provision Pathway</th>
<th>Advantages</th>
<th>Constraints</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bio-fortification</td>
<td>✓ One-time research cost</td>
<td>✓ Competition is reduced through import bans, thus risks pricing the poor out of the market</td>
</tr>
<tr>
<td></td>
<td></td>
<td>✓ Continued lower recurrent cost of seed certification after initial release of new varieties</td>
<td>✓ Encourages/promotes market monopoly by bigger local companies, leading to higher commodity prices</td>
</tr>
<tr>
<td></td>
<td></td>
<td>✓ Available/provided pro-vitamin A is converted by human body to Retinol as required, thus avoiding over-dose</td>
<td>✓ Likelihood of leading to exclusion of the need/vulnerable groups (rural and poor) due to price inflation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>✓ Besides the NFNC and/or Ministry of Health, other ministries are also involved in nutrition policy generation and implementation</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Mandatory Vitamin A Fortification</td>
<td>✓ Implemented by private Sugar companies</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>✓ Government only enforces and monitors</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>✓ Cost is borne by the consumer (i.e. consumer pays for the programme)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Vitamin A Supplementation</td>
<td>✓ Directly delivered to the target (vulnerable) groups</td>
<td>✓ Direct administration/delivery of pure Retinol leads to potential overdose</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>✓ All costs of supplementation are borne by the Government and donors</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>✓ High manpower costs to run the Programme</td>
</tr>
</tbody>
</table>
The production and promotion of Yellow-fleshed Cassava being considered the second-best most logical pathway as a solution to the problem of Vitamin A deficiency in Zambia is in view of the following:

- Cassava is the second most important crop grown in Zambia, after maize (predominantly grown in Luapula, Muchinga and Northern Provinces, including North-western and Western Provinces);
- Cassava contributes 38% of Zambia’s total human consumption requirements and is a staple food for at least 30% of the Zambian population;
- Cassava is grown by the largest category of farmers in the country, i.e. small-scale farmers; and thus in some regions within the Cassava-Belt, more than 80% of small scale farmer household populations depend on Cassava for food and nutrition security and for income-generation;
- Cassava production systems play a key role for farmers and a considerable proportion of households are involved in it including women both in farming, primary processing and trading; this is so important considering that women (studies have shown that particularly lactating women are among the most vitamin A-deficient population);
- More than 200 processed products can be derived from cassava roots and leaves; and these products have significant domestic, including international market potential.

3. **Innovation Description:**

The innovation is a technological work involving cross-breeding of naturally yellow cassava varieties with the locally preferred white cassava varieties, which are resistant to diseases. The naturally yellow varieties carry the genes that contain vitamin A (Beta-Carotene). The resultant progenies from the crossing carry, yellow in colour (a sign of containing Vitamin A) are then selected and tested for adaptation and consumer acceptability. The yellow-fleshed cassava varieties are sweet-tasting, making them easily/readily acceptable by consumers. The new varieties are able to produce Beta-Carotene, a precursor for Vitamin A. The Vitamin A is permanently carried in the resultant yellow-fleshed cassava plants which are then able to produce Carotenoids which could not be or were not possible to produce in the ‘old’ white-fleshed varieties.

The breeding process produces clones with genes that confer varieties with Vitamin A and the innovation is environmentally friendly as the breeding assumes the normal process of crop production (with no damage to the environment). The process, however, is rather long, taking about 6 to 7 years, and thus tends to be expensive, averaging about US$ 400,000 in variable costs. This cost is a major constraint, particularly to farmers, with regard to the ability to maintain the yellow-fleshed cassava tubers, coupled with the technical knowledge required.
4. Economic Feasibility /Benefits:
The production and consumption of yellow-fleshed cassava is an economic innovation, particularly to the Government, in the long run, in that there would be huge savings in terms of costs (in foreign currency) incurred in addressing the high prevalence of Vitamin A deficiency using the conventional medical treatment. The innovation would also take care of the most Vitamin A vulnerable rural population of children and lactating mothers, considering that cassava is one of the staple food crop and is relatively widely grown by small scale farmers with minimal input cost requirements.

Alleviating vitamin A deficiency in lactating mothers and under-five children is a social benefit to both women and children, in that they would be healthy and have enough time to engage in various socio-economic activities.

The innovation would also greatly contribute to the enhancement of household and national food and nutrition security, since a relatively high proportion of the Zambian population depend on cassava for food security and income generation.

5. Scalability:
Cassava being tolerant to effects of climate change, the yellow-fleshed cassava has high potential for scaling out to other non-traditional cassava-growing areas which are prone to drought. Additionally there is growing demand for yellow-fleshed cassava by consumers and increasing willingness to grow the crop by farmers.

The lengthy of the breeding process (6-7 years), on the other hand, could be a limitation to speedy scaling-up of the innovation.
6. **Name of Innovation: “Processing of Groundnut Shells into Bricks for Cooking”**

1. **Background:**
   Groundnuts are the number one legume crop grown by small scale farmers in Zambia, largely for consumption and for sale. The crop is mainly grown in Eastern Province of Zambia.
   The promotion of processing of groundnut shells into bricks and using them for cooking tries to address two problems: (i) the piling of huge groundnut shells as waste, and (ii) the issue of deforestation.
   Realization that deforestation was becoming a problem led to the policy formulation of discouraging the use of charcoal and/or firewood for cooking, in order to minimize the cutting of trees. Research findings have shown that 250,000 Ha to 300,000 Ha of land are deforested annually in Zambia (FAO’s Integrated Land-Use Assessment Report [ILUA], 2010), largely as a result of tree-cutting for use as firewood and charcoal for cooking. On the other hand a lot of groundnut shells are thrown and piled away as waste.
   Thus, in order to conserve forests, through the reduction of tree-cutting for use as firewood and charcoal, the innovation to utilise the groundnut shells (waste) was introduced as an alternative source of energy for cooking. The use of groundnut shells by making them into ‘bricks’ for cooking also works as a waste management practice. For example, from 100MT of groundnuts, 20-30% are shells which are then pressed into bricks to be used as fuel for cooking. The innovation has been introduced by the Community Markets for Conservation (COMACO) and is being practiced by communities working with it, largely in Eastern Province of Zambia.
   The implication of the situation before the innovation was/is that more trees were/would be cut for as firewood or charcoal, for cooking, exacerbating the problem of deforestation. If not used in this way for cooking, the groundnut shells are normally considered as waste and are thus disposed of either by burning or burying them or just heaped on the ground and left to rot naturally. Burning the shells produces a lot of smoke which is considered as air pollution and thus becoming an environmental problem and a health hazard to human beings (through breathing). Heaping them on the ground and left to rot naturally might result in breeding of disease-causing organisms to human beings and also the production of bad odour unpleasant to human breathing.

2. **Projected pathway to generation of solution:**
   A number of efforts have been introduced and/or being embarked and practiced aimed at minimizing and controlling deforestation caused by the cutting of trees, for various purpose, especially for use as energy source for cooking. Most of them involve or aim at promoting the use of alternative sources of energy for cooking.

   Some of these efforts include:
   - Use of electric and/or gas stoves;
- Awareness creation on the consequences of deforestation and encouraging planting and re-planting of trees;
- Using of energy-saving stoves which uses twigs;
- Cook Stove using of Gliricidia tree cuttings;
- Using of a certain type of bamboo for making charcoal; and
- Processing of Groundnut Shells into Bricks for Cooking.

**Use of electric and/or gas stoves:** this innovation has been in use for a long time and still in practice as a conventional and modern way of energy source for cooking. Much as it is still modern, convenient and easy to practice and also environmentally friendly, and generally cooks faster (compared to the other above listed ways), its limitations is largely the cost. The cost of both the stove and payments for the use of electricity and gas is or could be limiting especially in rural areas of Zambia (and generally in rural areas of developing countries), and particularly for the poor communities/households. Additionally, accessibility to both stoves and electricity/gas is difficult or not at all accessible because these facilities and services are not available or within the proximity of prospective users.

Thus, this innovation is more beneficial and applicable, generally to urban and affluent communities/households. On the other hand, with the recent occurrences of inadequate hydropower generation in Zambia, resulting in electricity load-shedding (electricity rationing), even urban communities are resorting to increased use of mainly charcoal as a supplementary source of energy for cooking. This is also coupled with the fact that the supply of gas is not reliable.

**Awareness creation on the consequences of deforestation and encouraging planting and re-planting of trees:** Various Government and Non-governmental institutions, including other non-state actors concerned/dealing with issues of environment and natural resources conservation from time to time do conduct various public awareness creation activities, on the negative effects of deforestation. These stakeholders thus educate the public on and promote the use of alternative sources of energy for cooking other than the use of firewood and charcoal. Additionally, tree planting and re-planting (afforestation) is encouraged.

Although this pathway has been going on for a very long time in discouraging the cutting of trees for firewood and/or charcoal, the efforts have not proved successful. However, it is slowly being appreciated, more so with the effects of climate change being experienced in recent times.

**Using of energy-saving stoves which use twigs:** the use of clay stoves specifically designed to use twigs from nearly all trees for cooking is another new innovation under promotion (refer to Chapter/Section C for more details/information on this effort).

**Using of Gliricidia tree cuttings:** the use of cuttings from the Gliricidia tree is another innovation being promoted for cooking. This innovation is also being promoted by COMACO. The innovation is not only aimed at providing a cheaper and alternative source of energy for cooking but is also
being used as a means to minimizing/addressing deforestation and encouraging the planting of Gliricidia trees also for improving soil fertility, as an agro-forestry practice (Refer to Chapter/Section H for more details on this innovation). As mentioned under the use of electric and gas stoves, above, electricity load-shedding is also negatively affecting the efforts of discouraging deforestation.

**Use of a certain type of bamboo for making charcoal:** the practice of using a certain type of bamboo for making charcoal for cooking instead of trees, is rather a new promising technology for becoming an innovation. This is under promotion by the Conservation Farming Unit (CFU). As this is currently a promising technology more efforts are need to encourage its practice in Zambia. One immediate challenge in its promotion is that this type of bamboo is being sourced from Kenya.

**Processing of Groundnut Shells into Bricks for Cooking:** COMACO is the one promoting this innovation among its community members in Eastern Province. The practice is largely or currently primarily being promoted in Eastern Province being the major province for groundnut production in Zambia and one of the areas where COMACO operates. This innovation is not only proving successful as a source of energy for cooking but also as a form of waste management (recycling of groundnut shells) after removing the nuts (the useful part of the crop). Thus the innovation has a double purpose, i.e. shells being made into briquettes for cooking at the same time as a means of disposal of the removed shells from groundnuts (which normally are thrown away and accumulate or pile up as waste). The shells disposal aspect as a form of waste management when used as a source of energy for cooking could be considered as an added advantage to the innovation; otherwise the shells are/could be disposed of by either just burning them or just burying them. Burning them contributes to environmental pollution by the produced smoke (and thus is/would be discouraged). On the other hand, burying them could be positive as adding manure to the soils (although the common burying of shells is not intended for this purpose, but as a mere form of disposing them as waste). Additionally, the ash from the burnt briquettes after cooking can also be used as organic fertilizer to add potash to the soil.

The drudgery or constraining factors to the practice of the innovation include the high/too much smokes emission when cooking and the spare parts for the pressing machine are scarce or not easily found (for use to repair pressing machine when it breaks down). Although not yet ascertained (during this study) the design and cost of the pressing machine itself might be a limitation (especially to the poor users of the innovation; in the case of Zambia, the main groundnut producers are small scale farmers, who generally are poor). In terms of gender, more women are involved in its utilization of the innovation (it may thus be looked at as more female-gender friendly).

Considering the pros and cons of all the above pathways of energy sources for cooking, as outlined under each pathway, it is quite difficult to come up with the general most logical pathway to the solution. Each one of the pathways would qualify or be recommended as a
localized most logical pathway, depending on the various prevailing social, economic, geographical, environmental factors etc. some of which could be inherent or circumstantial.

In the case of Zambia and specifically for Eastern Province, this innovation could be recommended as the most logical pathway as a source of energy for cooking, and particularly among the small-scale groundnut producers.

3. **Innovation Description:**
The innovation involves the use of groundnut shells, which are normally considered as waste. After removing the nuts (which are the main or normally utilized parts of the crop) from the harvested groundnuts, the shells are gathered and pressed into briquettes (bricks) using a pressing machine and the bricks are then used for cooking (as a substitute for firewood or charcoal).

This is a technical innovation aimed at providing alternative energy for cooking and at the same time helping in the conservation of tree, thus addressing or minimizing de-forestation.

On the other hand it is a form of solid waste management, as the groundnut shells are normally thrown away as waste. In areas where groundnuts are produced in abundance, like in the Eastern Province of Zambia, instead of throwing the shells away, they are in a way ‘recycled’ and used as a source of energy for cooking. Thus, the innovation also serves as way of disposal of ‘waste’ shells.

Additionally, in both ways, as an energy source for cooking and a form of waste (shells) disposal this innovation is technical.

The innovation very much benefits (elaborated more under the economic benefits’ section below) especially the rural communities in that they save on:

- financial resources for buying cooking materials;
- time spent on looking for alternative cooking materials and required for the common disposal of shells, e.g. burying;
- minimizes environmental pollution brought about by burning shells as one of the disposal methods;
- contributes to human health promotion by avoiding inhalation of a lot of smoke and smoke irritation (choking) as a result of burning of shells as another disposal method, and also avoiding bad smell which may result from the rotting of shells when left heaped on ground to rot.

The innovation is socially accepted and is generally environmentally friendly. It is also economically sustainable especially in areas where a lot of groundnuts are grown. The innovation is easy to operate with minimum labour, i.e. cooking.

The innovation has, however, some drudgery and constraints to its practice such as: cooking still produces some smoke; thus there is need to look in how best to reduce on this smocking; spare parts for the pressing machine are not easily found or may not be availability; socially not very
acceptable in that manual groundnut-shelling is labourious and that more women than men are involved.

Design and cost of the pressing machine although not ascertained (at time of study) might also be drudgery factors of the innovation.

4. **Economic Feasibility /Benefits:**
The innovation has a number of economic, social and environmental benefits such as the following:

- No additional cost to the users of the innovation for the materials (shells) used for cooking, besides the money invested or put in groundnuts production; thus, in this respect they is money-saving.

- Time-saving: it saves on the time spent on sourcing/looking for the materials used for cooking, e.g. firewood, charcoal, buying kerosene etc., since the groundnut are normally shelled within the vicinity after harvesting (for small scale farmers, shelling is usually done at homesteads). The saved time can be utilized for other socio-economic engagements.

- The ash from the burnt briquettes after cooking can also be used as organic fertilizer to add potash in the soil.

- The innovation takes care of or minimizes some environmental and human problems (thus socially accepted), such as:
  - the much smoke which is considered as air pollution (environmental problem) and a health hazard to human beings (through breathing), i.e. the smoke produced when the groundnut shells are disposed of by burning;
  - bad odour unpleasant to human breathing, i.e. the bad smell produced when groundnut shells are heaping on the ground and left to rot naturally; and
  - disease-causing organisms to human beings, i.e. disease-causing organisms which are or might be produced/bred as a result of groundnut shells heaped and left to rot naturally on the ground.

  I. It reduces on tree-cutting for firewood and charcoal, thus minimizing deforestation and also reducing on the effects of climate change, which could be costly both to individuals and to governments.

  II. Is a form of good waste management, thus reducing on pollution and putting to good use what is normally regarded as waste (shells).

5. **Scalability:**
The innovation has high potential for scaling up and out in areas where there is high production or production potential of groundnuts (easy and adequate availability of shells for use). Also, in areas/places where production is low or no production at all but there is high demand for groundnuts in unshelled form (shells could be utilised in such places when shelling is done).

On the other hand scaling out of the innovation to other areas, i.e. geographical areas, is or would be limited such as where groundnuts production is low; and like in the Zambian case, groundnuts
are not grown in all parts of the Country and as such there may not be adequate materials (shells) to use or distribute. Transportation of shells and other logistics may also come in as a challenge. Another limitation to scaling up and out is that groundnuts are a seasonal crop and as such when groundnuts are not in season availability of shells would be a problem: on the other hand, storage issues of shells may also be another challenge.

With these issues above, the innovation would rather be a localized recommendation to areas where groundnuts production is high, e.g. Eastern Province of Zambia; and/or where there is potential for production or increased production (where production is low). Also, where large quantities of unshelled groundnuts are bought and shells are just thrown away or burnt as waste.

H. Name of Innovation: “Cook stove using Gliricidia cuttings”

1. Background:
Studies indicate that Zambia has approximately 50million hectares (Ha) of forests and 250-300Ha were/are being deforested annually (ILUA Report, 2010). Deforestation rate in Zambia is reported at 1.5% per annum and the Country is ranked among those with the highest rate of deforestation in the world (Henry et al 2011).

This high deforestation rate is largely due to the cutting of trees for charcoal and firewood. Thus the Government is reinforcing policies to stop or minimize deforestation, involving various stakeholders. Consequently COMACO came up with the cook stove which uses Gliricidia tree cuttings. This initiative also aimed at saving on the time and labour, especially for women in Eastern province, spent on looking for firewood and charcoal for cooking.

Thus the initiative/innovation has not only contributed to reduction in the rate of deforestation but also provided alternative and relatively cheaper source of energy for cooking.

COMACO promotes the growing/planting of Gliricidia tree among its target communities as a means of afforestation, fuel source for cooking and organic manure for enriching the soils. According to COMACO, one Lima of land (¼ Ha) of Gliricidia trees produces enough woodlot to cater for a six-member family for a year.

2. Projected pathway to generation of solution:
The objective of minimizing deforestation (through the cutting of trees for firewood and charcoal) and providing or encouraging other alternative sources of energy for cooking has been or is being pursued by the government and other various stakeholders by a number of different pathways. The current and common ones in practice, besides the cook stove using Gliricidia cuttings, are the five to six innovations mentioned in the Chapter/Section G, above, i.e.

- Use of electric stoves;
- Use of gas stoves
- Using of energy-saving stoves which uses twigs;
- Processing of Groundnut Shells into Bricks for Cooking; and
Awareness creation on the consequences of deforestation and encouraging planting and re-planting of trees;
- Using of a certain type of bamboo for making charcoal (promising technology being promoted by CFU).

Refer to Chapters/Sections C and G for the advantages, constraints and descriptions of the listed above.

**Cook stove using Gliricidia tree cuttings:** the generation process of the innovation starts by planting of Gliricidia trees in the field followed by the setting up of the cook stove known as the **COMACO TLC Rocket Stove**. The small branches (cuttings) from the Gliricidia tree are cut/harvested as firewood to be used in the stove. The Gliricidia trees are planted by local people (COMACO’s project beneficiaries/farmers) in COMACO’s operating areas (Eastern and Muchinga Provinces). The cook stove cost about US$25 to make. COMACO has a target of putting up 100,000 cook stoves for Eastern Province and 20,000 for Muchinga Province.

The cost of making the stove is or could be beyond the financial capabilities of most rural people for who the innovation is intended. Additionally, the technicalities involved in the making process of the stove is or could be a disadvantage to most rural communities (rendering the innovation not easy to practice and thus adopt). Considering the long period trees normally take to grow and mature.

Considering the costs and other issues connected to the usefulness and applicability of the cook stove using Gliricidia tree cuttings and innovations (a), (b), (c) and (d) listed above, none of them could individually be singled out as the most logical pathway to the solution. Each one of these innovations could be recommended as a localized most logical pathway, depending on the various prevailing social, economic, geographical, environmental factors etc., these factors of which could be inherent or circumstantial.

The pathway of “Awareness creation on the consequences of deforestation and encouraging planting and re-planting of trees” is a general and easy approach to addressing or minimizing deforestation, but when it comes to providing the alternative to the use of firewood or charcoal for cooking, any of the six (6) pathways could be recommended, again considering the prevailing social, economic, geographical, environmental factors.

On the other hand, the promising technology of “using a certain type of bamboo for making charcoal for cooking” may appear to be the most logical pathway to the solution. One major challenge at the moment, could be the sourcing of the seed/planting material for the type of bamboo used for making the charcoal: at the moment, CFU (the currently researching institution in Zambia) is sourcing or has obtained it from Kenya. If adequate planting material for this type of bamboo could be procured/sourced and easily from Kenya and adapted for multiplication in Zambia, this could probably be the most logical pathway, in the long run (notwithstanding the procurement process and cost of the planting material which has not yet been established from CFU).
3. **Innovation Description:**
The Cook stove using Gliricidia tree cuttings is a technical innovation. The cooking materials are cuttings from Gliricidia trees, thus the innovation starts with the growing/planting of Gliricidia trees. The growing/propagation of Gliricidia trees starts with raising the seedlings in nurseries and managing them and then transplanted into the main field where they grow and mature into trees to produce branches from which cuttings are taken to put in the stove for cooking when needed. The cuttings from the Gliricidia tree have to be dried (if cut fresh) in order to be used in the stove or have to be cut from the tree as dry branches and then used/put directly in the stove for cooking. That is the cuttings are used as firewood (instead of big tree pieces). The Gliricidia trees are not only planted for their cuttings but also as agro-forestry trees for organic soil fertilization in farming fields.
The COMACO TLC Rocket cook stove which uses the Gliricidia cuttings is made using 15 small burnt bricks (22cm x 11cm x 6.5cm in size). The Cook Stove is 28cm high, 34.5cm wide and 34.5cm long when completely made (i.e. the size of the cook stove). The cook stove is constructed/made by trained people (however, may require assistance from other non-trained people such as people from the local communities where the stoves are used). The making process takes one and half days. The cost of making the stove is about twenty five United States Dollars (US$ 25).
The innovation is socially accepted (especially by the women folk, as it reduces the number of hours they spend on looking for fire wood and charcoal for cooking; household time saved is estimated to be 40%, which is thus allocated for other socio-economic engagements), environmental friendly and cooking is easy with less smoke. Thus the innovation is a great improvement for farming households’ livelihood. The innovation is sustainable as long as the expansion of the Gliricidia planting is done.
The innovation has however, some issues which could be considered as drudgery and constraints to its practice such as:

- The relatively high cost of making the cook stove (currently said to be US$25);
- The making of the stove requires some technical skills through training;
- There is some smoke produced from cooking, although not much, which could be irritating (and probably may be a health risk in the long run with prolonged usage);
- the propagation of the Gliricidia plants and managing Gliricidia nurseries requires active attention and some technical knowledge;
- Sustenance of the innovation requires planting of many trees and thus the need for bigger/larger land sizes; and
- Gliricidia trees, like other trees, normally take long to grow and mature to produce the branches from which cuttings have to be obtained for use in the stove for cooking.

4. **Economic Feasibility /Benefits:**
The main innovation’s benefit is the time saved by the use of cuttings from Gliricidia trees for cooking instead of looking for firewood or charcoal. It is reported that about 40% of time is saved.
in this way and thus a major benefit especially for women. The saved time is spent on other socio-economic activities.
The innovation is also multipurpose, that is, it is helps in or used for cooking, reduction in deforestation and improving soil fertility.
In the planting and use of Gliricidia trees (as agro-forestry trees), farm households derive economic benefits from increased crop production of various agricultural enterprises the farming households are engaged in; increased crop production also contributes to enhanced household and/or national food and nutrition security.
The use of tree cuttings for cooking instead of big trees for firewood or charcoal contributes to minimizing climate change effects through minimized deforestation (as a result of reduced tree cutting). Additionally, the planting of Gliricidia trees not only improves soil fertility but is also one way of afforestation (increasing forest cover).

5. **Scalability:**
With its multi-benefits the innovation has some good potential for scaling up and out, notwithstanding the cost and technical skills involved in the making of the cook stove and the management and attention required in the propagation of the Gliricidia trees.
I. References


## List of Persons Contacted

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