NARI Full Project Proposal (Revised October 20)

NARI Program/Sub-program/SPIP project; which ADDs/Clusters	Program 1: Agricultural Systems Subprogram: 1.4: Land and soil fertility management SPIP: 1.4.2: Soil fertility management in vegetable systems ADDS/Clusters: All clusters
Concise but explicit title for the proposed project	Assessing the effectiveness of Grow Hariap Foliar Fertilizer (GHFF) in managing crop productivity relative to conventional fertilizer practices.
Project Leader and other members of research team	Project Leader: Philmah Waken (SRC), Project team: William Sirabis (HRC), Ruth Baiga (MRC), Dickson Benny (SRC), Raywin Ovah, Clifton Gwabu (MRC).
Estimated duration of the project	2 years (3 seasons each site)
Total budget	

Name and Acronyms of Partner organisations working on the proposed project.	
a)	
b)	
c)	

List of target locations in which the proposed project will be implemented.	
a)	Southern Regional Centre, Laloki
b)	Momase Regional Centre, Bubia
c)	

1. Summary of Research Questions

Briefly summarise in dot-point form the problems/opportunities and associated research questions that the project is attempting to address (max 100 words)

Grow Hariap Foliar Fertilizer (GHFF) is a new locally made fertilizer available via the market for use in PNG. Farmers' testimonials on social media claim increased productivity and improved quality. However, there is insufficient empirical data to justify these claims. The manufacturer insists that it is enriched with essential nutrients for any plant type in PNG.

This proposed study addresses these research questions:

1. Does GHFF increase crop productivity and quality?
2. How does the product work given our current understanding of the physical, chemical and biological mechanisms that interact in soil-plant ecosystems?
3. Is GHFF more economically beneficial relative to conventional recommended fertilizers?

2. Summary of Background/Literature review (max 500 words)

- Provide a summary of key information coming from the consultation of relevant literature and other information sources on the identified Issues, Problems and Opportunities that will be addressed by the proposed project including any work that has already been done. The summary of the background information needs to clearly emphasise on the research gaps and which ones will be addressed by the project.
- Where appropriate, attached the full background information/literature review as Appendix 1 with this proposal

Issue

Today many products claiming to be alternative plant fertilizers are marketed without scientific evidence of its effectiveness on crop production. Consumers are left to believe promotional advertising, as well as confide in experience. Many of these products prey on lack of knowledge or ignorance by the user. A locally made fertilizer, Grow Hariap Foliar Fertilizer is currently in the PNG markets, available for farmer use. The manufacturer insists that it is enriched with essential nutrients for any plant type in PNG. However, there is no available empirical data to validate these claims.

Problem

Alarmingly, fertilizers, activators, growth stimulators, vitamins, and hormones do not need efficacy testing while pesticides must submit efficacy research data before the products are registered for marketing (Wehr, 2017). Consequently, nostrum products commonly appear in markets, and the efficacy of GHFF has yet to be scientifically proven with empirical data. Most persuasive nostrum products are based partly on a sound scientific principle with copious amounts of jargon (Billingham, 2012). The application of scientific evaluation to confirm or challenge the manufacturers' claims is crucial to ensure that farmers base their decision to invest scarce funds on sound information.

Opportunities

The proposed study will contribute to:

1. Increased knowledge of the viability of a PNG Made agriculture product using sound scientific methods.
2. Enhanced knowledge of the performance of conventional fertilizer management practices and locally produced fertilizers to manage production and quality of horticultural crops.
3. Promote the marketability of a PNG Made product.
4. Capacity building in research and analytical skills involving interactions in the soil-plant ecosystems for researchers directly involved in the project.

3. Target Beneficiaries

Describe who the primary beneficiaries are; where are the target communities located (reference to ADD clusters) and why target them;
[1]note: primary project or target beneficiaries are not always farmers but can include other researchers, extension workers, policy makers, developing agencies, agribusiness operators etc.

Primary project beneficiaries at this stage are agriculture research and extension personnel directly involved in activities of soil nutrient management options. The information generated will be for the purpose of advising best nutrient management practice(s) for optimum crop productivity and farmer trainings.

An alternate beneficiary is the producer of the GHFF – sound scientific data endorsing the product's efficacy should promote its marketability

Secondary beneficiaries are the smallholder producers of commercial horticultural crops from the highlands, low dry land, low wetland and coastal areas of PNG. The use of fertilizers has played a significant role in increasing crop productivity and farm profitability per unit area. Therefore, the results of this study will provide smallholder farmers information of appropriate affordable fertilizers that can be used to manage production, quality and profitability to maintain their farming communities.

4. Project Goal

State the Goal of this project – the Goal should be consistent with the NARI Results Framework, i.e. it would reflect the next higher level to where the project is contributing. In most cases this would be the relevant Project (SPIP) objective or Program Objective in case of large projects.

Smallholder farmers' knowledge and choice of appropriate fertilizer inputs improved and safe guarded from the lure of unverified market driven product claims.

5. Strategic Objective

State the Strategic Objective – this should be one concise statement expressing what will have been achieved or changed by the successful completion of the project for the target beneficiary group(s)

Improved information on the viability of GHFF and conventional fertilizer management practices readily available and disseminated to smallholder horticultural crop producers for best practices to increase crop productivity, quality and profitability.

6. Project description

Broadly describe:

a) Expected major research outputs of the project[1]
b) Outputs and activities
c) Methodology including, experimental design or survey methodology, analytical techniques, data collection and analysis (whatever is applicable) and reasons for choice of methodology
d) Implementation arrangements
e) Role of NARI and other partners (if applicable)
f) Logical Framework (Annex 2)
g) Gantt chart (Implementation schedule)

a) Expected major outputs of the project.

1. GHFF's ability to improve crop productivity and quality compared to locally available conventional fertilizers is scientifically validated.
2. Economic benefit of the use of GHFF and other locally available fertilizers for smallholder farmers' use is determined.

b) Outputs and activities

Table 1: Expected outputs and activities

Expected Outputs	Activities
Output 1: Generate information on GHFF's ability to increase crop productivity and quality.	Experimental trials in SRC, & MRC for three seasons of indicator crops per site. Treatments will include respective commercial fertilizers for the respective crops and GHFF.
Output 2: Generate information on the cost and profit analysis of the use of GHFF compared to other locally available conventional fertilizers for smallholder farmers' use	Experimental trials in SRC, & MRC for three seasons of indicator crops per site. All variable and fixed cost for production including materials, labour, inputs etc. will be recorded. At harvest, marketable produce from the harvest will be sold and revenue recorded. Profit will be calculated.
Output 3: Reporting and recommendations of appropriate fertilizer use to increase crop productivity and quality.	Technical Report - Compiling data, analysis, and interpretation. Reporting on the reliability of GHFF and other locally produced and sourced fertilizers for smallholder farmers' utilization.
Output 4: Publications - Research information and dissemination	1. Seminar workshop to present findings to producer of GHFF, Provincial DAL extension officers, FPDA and other NGOs with agriculture and livelihood programs from each site (SRC, & MRC) to disseminate research findings. 2. NARI Nius 3. Focus Column 4. NARI Toktok 5. National/regional conferences

[1]Research outputs are but not limited to: a technology, best practice, a new variety, livestock breed, new information, a strategy, policy recommendations, a new approach, business model, lab method/assays, guidelines, decision-support tools, improved understanding, evidence of profitability, effectiveness, feasibility etc., tools to measure, assess, record, monitor etc., maps, inventories, management package, regulatory framework, standards, a network, etc……. …….....

	6. Journal publication(s) (working titles) a. Efficacy of GHFF and conventional fertilizer management practices to improving commercial vegetable production in Papua New Guinea. b. Cost & profit analysis of GHFF vs locally available commercial fertilizers.

c) Research methodology

Fertilizer efficacy trials

1. Experimental sites: Selection of suitable sites.
2. Soil testing:
    a) Cover crop of corn to be planted after site selection to run down soil nutrient of pre-existing soil conditions in selected sites.
    b) Initial soil sampling and collection after corn harvest in selected sites.
    c) Samples from three sites will be sent to Prof John Kola Chemistry Laboratory, Kilakila for testing.
    d) Soil sampling and testing after final season of planting.
3. GHFF Nutrient testing:
    a) Initial GHFF nutrient testing to confirm product claims.
    b) Samples will be sent to Prof John Kola Chemistry Laboratory, Kilakila for testing.
4. Indicator crops per site are chosen based on most common commercial crop species in each study site to evaluate efficacy of the treatments.
    a. SRC – Chinese cabbage (Commercial varieties -Pakchoi, Green boy or Tsoi sum) and Sweet Corn (Hybrid variety)
    b. MRC – Capsicum (Commercial variety) and sweet potato (Beauregard)
5. Treatments will differ according to the conventional fertilizer crop requirements against the use of GHFF. GHFF application and use will be as specified according to product label. Table 2 specifies treatments for each indicator crop. The Control treatment will be a plot with no fertilizer application.

Table 2: Treatments

Site	Crop	Treatments
SRC	Chinese cabbage	1. Control – no fertilizer application
		2. Urea (N)
		3. Lactobacillus Fertilizer
		4. Grow Hariap Foliar Fertilizer (GHFF)
	Sweet Corn	1. Control – no fertilizer application
		2. NPK
		3. Lactobacillus Fertilizer
		4. GHFF
MRC	Capsicum	1. Control – no fertilizer application

		2. NPK
		3. Lactobacillus Fertilizer
		4. GHFF
	Sweetpotato	1. Control – no fertilizer application
		2. NPK
		3. Lactobacillus Fertilizer
		4. GHFF

6. Experimental design – The trials will be laid out in a randomized complete block design with five replications.
    a. Chinese Cabbage – Each gross plot will have 40 plants. There will be 4 rows with 10 plants per row. Spacing between rows will be 0.6m (4 x 0.6m = 2.4m width) and spacing between plants will be 0.4m (10 x 0.4m = 4m length) in each row. Total gross plot size will be (2.4m x 4m = 9.6m^2). The net plot will be made up of the plants from the second and third rows, particularly the eight middle plants in each row; therefore there will be a total of 16 plants. Net plot dimensions will have a width of 0.6m (row spacing) and a length of 3.2m (0.4m x8), a total net area of 1.92m^2 (0.6m x 3.2m) for each treatment. The trial will be replicated 5 times. Spacing between blocks will be 1m apart with 0.5m spacing between plots. One block size will be 4m in length and 11.1m in width [(2.4m x 4 plots= 9.6) + (0.5m X 3 = 1.5m)]. Therefore the total trial site width will be 11.1m and the length of the field will be 24m [(4m x 5 blocks) + (1m x 4 = 4m)]. The total area of the trial will be 266.4m^2 (11.1m x 24m).

    b. Corn – Each plot will have 4 rows planted with row spacing of 0.7m and between plant spacing of 0.5m. Each plot will have 40 plants with 10 plants in each row. Plot width of 2.1m (0.7m x 3), and plot length of 5m (0.5m x 10). Gross plot area of 10.5m^2 (2.1m X 5m). Net plot will consists of the middle eight plants of the second and third rows (16 plants). Net plot width of 0.7m and length of 4.5m (0.5m X 8), a net plot area of 3.15m^2 (0.7m x 2.4m). Space between blocks will be 1m while spacing between plots will be 1m. One block will have four treatments therefore, the length of the block will be 5m (0.5m x 10) and the width of the block will be 11.4m [(2.1m x 4 plots) + (1m x 3)]. The size of one block area is 57m^2 (5m x 11.4m). Therefore the total trial site area will be 330.6m^2 [(5m x 5 blocks) + (1m x 4) x 11.4m).

    c. Capsicum - Each plot will have 4 rows planted with row spacing of 0.75m and between plant spacing of 0.4m. Each plot will have 40 plants with 10 plants in each row. Plot width of 2.25m (0.75m x 3), and plot length of 4m (0.4m x 10). Gross plot area of 9m^2 (2.5m X 4m). Net plot will consists of the middle eight plants of the second and third rows (16 plants). Net plot width of 0.75m and length of 3.2m (0.4m X 8 plants), a net plot area of 2.4m^2 (0.75m x 3.2m). Space between blocks will be 1m while spacing between plots will be 0.6m. One block will have four treatments therefore, the length of the block will be 4m (0.4m x 10) and the width of the block will be 10.8m [(2.25m x 4 plots) + (0.6m x 3)]. The size of one block area is 43.2m^2 (4m x 10.8m). Therefore, the total trial site area will be 259.2m^2 [(4m x 5 blocks) + (1m x 4) x 10.8m).

    d. Sweetpotato – Each plot will have four 4m rows with 0.7m spacing between rows and 0.4cm spacing between plants. Each plot will have 40 mounds with 10 mounds in each

row. Gross plot area of 8.4m^2 (4m X 2.1m). Net plot will consists of the middle eight plants of the second and third rows (16 mounds). Net plot width of 0.7m and length of 3.2m (0.4m x 8 mounds), a net plot area of 2.24m^2. There will be five blocks. One block will have four treatments. The length of one block will be 4m and the width will be 11.4m [(2.1m x 4 plots) + (1m x 3). The size of one block area is 45.6m^2 (4m X 11.4m). Spacing between each block will be 1m, therefore, the total trial site area will be 273.6m^2 [(4m x 5 blocks) + (1m x 4 block space)] x 11.4m)

Data collection parameters

Table 3: Chinese Cabbage evaluation data

Variable	Measured as:
Days to 50% emergence	50% of plants with cotyledons open above ground
Total emergence	% of seed planted that has emerged
Developmental Stage	Recorded for each assessment
% Sibs	Sibs are low vigour plants that do not grow well. Percentage of totalplant out
Plant height	Height of plant (cm)
Days to first harvest	Days from transplanting
Days to 50% harvest	Number of days from transplanting that 50% of plants have been harvested
Number of harvests	No. of cuts required to harvest all plants.
Gross yield / net yield	Fresh weight (g)
Marketable yield	Marketable fresh weight (g)
Pest & disease	Rating 1-5 of type, symptoms, incidence and yield reduction 1=no incidence; 1-2 = low incidence rate; 3-4 = medium to high incidence rate; 5 = highly infected Soft-rot disease: Rating: 0-3 scale: 0, no leaves affected; 1, old leaves only affected; 2, old leaves and wrapper leaves affected; 3, whole plant affected.

Table 4: Corn evaluation data

Variable	Measured as
Days to 50% emergence	50% of plants with cotyledons open above ground
Total emergence	% of seed planted that has emerged
Developmental Stage	Recorded for each assessment
% Sibs	Sibs are low vigour plants that do not grow well. Percentage of total plant out.
Plant height	Height of plant (cm)
Days to 50% flowering	Number of days from planting that 50% of plants have been flowered
Stand count at flowering	Number of stands counted at >50% flowering stage
Days to first harvest (50% maturity)	Days from transplanting
Days to 50% harvest	Number of days from transplanting that 50% of plants have been harvested

Stand count at harvest	Number of stands counted at harvest
Average number of cobs per plant	Number of cobs counted per plant at harvest
Gross yield (ton/ha)/net yield	Fresh weight (kg)
Marketable cobs (ton/ha)	Fresh weight (kg)
Unmarketable cobs (ton/ha)	Fresh weight (kg)
Pest & disease	Rating 1-5 of type, symptoms, incidence and yield reduction 1=no incidence; 1-2 = low incidence rate; 3-4 = medium to high incidence; 5 = highly infected

Table 5: Capsicum evaluation data

Variable	**Measured as:**
Days to 50% emergence	50% of plants with cotyledons open above ground
Total emergence	% of seed planted that has emerged
Developmental Stage	Recorded for each assessment
Vegetative adaptation	Scale 1-5 (measure at).Inter-nodal distance, strong stem etc.
Days to flowering	50% anthesis
Fruitset	% flowers that set fruit
Days to 50% maturity	Days from transplanting at which 50% of plants have green mature fruit.
Partitioning	Vegetative and reproductive plant part dry weight
Reproductive adaptation (fruit load)	# of fruit, fruit shape, fruit fresh weight, fruit length and width
Gross yield / net yield	Fresh weight (g)
Pest & disease	Rating 1-5 of type, symptoms, incidence and yield reduction 1=no incidence; 1-2 = low incidence rate; 3-4 = medium to high incidence; 5 = highly infected
Survival at harvest	% of emerged stand still alive at the end of the crop

Table 6: Sweet potato evaluation data

Variable	**Measured as:**
Vegetative adaptation	
Vine length	Length of vine in cm
Vine thickness	Thickness of vine in mm
No. Of nodes	Number of nodes on vine
No. Of leaves	Number of leaves on vine
Fresh weight	Vegetative fresh weight (kg)
Days to first harvest	Number of days after transplanting
Partitioning	Vegetative and reproductive plant part dry weight
Reproductive adaptation	
Number of storage roots	Number of storage roots harvested per mound
Storage root length	Length of storage roots
Storage root diameter	Diameter of storage roots
Gross yield / net yield	Fresh weight (kg/tonne)
Marketable storage roots	Fresh weight (kg/tonne)
Non marketable storage roots	Fresh weight (kg/tonne)

Quality	1 -2 = Very good market quality (shape & size 4-9cm diameter); 3-4 = Good market quality (9cm > diameter); 5=Poor market quality (malformed/distorted roots).
Pest & disease	Rating 1-5 of type, symptoms, incidence and yield reduction 1=no incidence; 1-2 = low incidence rate; 3-4 = medium to high; 5 = highly infected

Statistical analysis

Analysis of variance will be conducted using GenStat 20th Edition. Table 6 below shows the skeleton ANOVA.

Table 6: Skeleton ANOVA

Source of Variance	Degree of freedom	SS	MS	VR	F
Replication	4 (5-1)	***	***	***	***
Treatment	3 (4-1)	***	***	***	
Error	8 (T-1) (r-1)	***	***		
TOTAL	15 (Tr-1)	***			

Partial Budget Analysis

The application of Partial Budget Analysis

A partial budget helps farm owners/managers evaluate the financial effect of incremental changes. A partial budget only includes resources that will be changed due to new technology. It does not consider the resources in the business that is left unchanged. Only the change under consideration is evaluated for its ability to increase or decrease income in the farm business. In our case, the change is the switch from a usual fertilizer to GHFF or from non-use of any fertilizer previously to adoption of GHFF.

Partial budgets are based on the principle that small business changes have effects in one or more of the following areas.

1. Increase in income
2. Reduction or elimination of costs
3. Increase in costs
4. Reduction or elimination of income

The net impact of the above effects will be the positive financial changes minus the negative financial changes. A positive net indicates that farm income will increase due to the change (adopting of GHFF), while a negative net indicates the change (adopting of GHFF) will reduce farm income.

Partial Budget Components

A partial budget consists of two columns, a subtotal for each column and a grand total. The left hand column has the items that increase income while the right hand column notes those that reduce in-

come for a farm business. The budget can be divided into four parts.

1. Added Income due to adoption of GHFF. This area is usually an estimate if a new enterprise is to be added. This could include crops yields, product quality, and prices; and mostly average figures from the range of realistic figures will be used. This means baseline information will have to be generated.

2. Reduced Costs due to adoption of GHFF. Obvious items for inclusion in this section would be crop expenses no longer incurred. These costs could be reductions or total elimination of certain expenses. Examples include seed, custom work, repairs, veterinary expense, interest expense and paid labor. Inclusion of non-cash costs such as unpaid labor and depreciation would provide a full economic.

3. Reduced Income due to adoption of GHFF (Income forgone from the next alternative fertilizer). Items to include here might be reductions in product sales, such as sweetpotato, capsicum, or Chinese cabbage that were generated when using the alternative fertilizer. This could be a potential income or actual income forgone.

4. Added Costs due to adoption of GHFF. This is the first section of Column 2. List all increased expenses due to the change being considered. Most of these will be costs of production for the new input – in this case GHFF.

Components 1 & 2 above (Table 7) measure the positive impact of adopting GHFF whilst components 3 & 4 measure the negative impact. If the net impact (difference between sum of 1&2 and the sum of 3&4) is positive then the new fertilizer (GHFF) shall be recommended for farmers to use; if it is negative, it should not be recommended.

Table 7: Partial budget components

Positive Impact	**Negative Impact**
1.Added Income due to GHFF Returns • Total harvested yield (kg/ha) • Marketable yield (kg/ha) • Yield per plant (kg/plant) • Average price (PGK/kg)	3. Reduced Income • Need to generate this from information on station (revenue or other previous research outputs, or from farmers, for the alterative fertilizer.
2. Reduced Cost • Need to generate this from information on station (revenue or other previous research outputs, or from farmers, for the alterative fertilizer.	4.Added Cost due to GHFF Crop establishment • Land preparation • Land clearing (man days) • Ridging (man days) • Bed preparation (man days) • Tractor services • Others (establishing irrigation (man days) soil test)

	Planting materials • Seeds per hectare Crop care • Fertilizers (40kg/1L bottles) • Fungicides (packets/bottles) • Herbicides (packets/bottles) • Others (packets/bottles) • Fuel for maintaining farm equipment (e.g. brush cutter) Maintenance labor • Planting (man days) • Fertilizing (man days) • Pesticide applications (man days) • Weeding (manual – man days) Harvesting • Harvesting (manual – man days) • Transport from field to market Overhead • Spray cans & PPE • Irrigation system • Tractors • Others

d) Implementation arrangements

The study will be conducted at two NARI research centers as a representative of different agro-ecological zones of the country. In each site, SRC and MRC, implementing scientists identified will be conducting the study in two parts - Agronomy trials and Cost profit analysis. Scientist in HRC, Mr. William Sirabis will also contribute to the project activities through consultation and advice on the Agronomy trial aspect.

e) Role of NARI

NARI scientists are to take lead in conducting the field research and soil nutrient at the Prof. John Kola Chemistry laboratory.

f) Logical Framework (Annex 2)
Refer to Annex 2

g) Gantt chart (Implementation schedule)

Research activities	Output/ Milestone Date	Month (2022)												Month (2023)											
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Preparation – procurements of research materials/resources	Jan – Feb 22																								
Season 1 (S1): Field preparation	Mar-22																								
S1 Nursery – Field planting	Mar– Apr 22																								
S1 Management & data collection	May – August 22																								
S1 Sampling & Harvesting	Sep-22																								
S1 Data processing	Oct-22																								
S1 Report preparation	Nov-22																								
S2 Nursery – Field planting	Oct - Nov 22																								
S2 Management & data collection	Dec 22 – Mar 23																								

S1 Sampling & Harvesting	Apr-23																							
S2 Data processing	May-23																							
S2 Report preparation	Jun-23																							
S3 Nursery – Field planting	May – Jun 23																							
S3 Management & data collection	Jul – Sept 23																							
S3 Sampling & Harvesting	Sep-23																							
S3 Data processing	Oct-23																							
S3 Report preparation	Nov-23																							

7. Monitoring and Evaluation

a) Discuss what beneficial direct, immediate and medium-term term outcomes are expected from the delivery of the proposed project strategic objective (complete Annex 2 Results Chain)

b) Identify any sources of baseline data, how you will collect this or how you will achieve a baseline

c) Explain what indicators you will use to measure outcomes against the baseline

d) Identify any sources of extra information that will assist you in judging the changes your project might bring about

a) Refer to completed Annex 2 Results Chain

b) There are currently no sources of baseline data validating the efficacy of GHFF against other conventional fertilizers in Papua New Guinea. However, there is literature on similar products

elsewhere that can be researched through desktop study. A collation of past and present research will serve as a baseline for comparison.

c) As indicated above, there is no baseline data therefore a key indicator to be used to measure the outcomes is GHFF showing that it does have an effect to increase in crop yield and quality and its utilization is cost effective.

d) The responsible utilization of social media platforms such as Facebook, personal interaction with users of the product and wide literature search will assist in judging the changes this study might bring about.

8. Risk Assessment

a) Identify all of the significant risks associated with the project
b) Assess the probability and impact for each risk
c) Give details of the way in which the organisation will manage the risks

Refer to completed Annex 4 Risk assessment matrix

9. **Cross-cutting Issues (Gender and Social Inclusion) – *may not be applicable to every project***

Conduct a gender analysis for the planned project interventions; consider

a) the roles of women and men and how their respective activities affect the issue you want to address
b) the roles of women and men in regards to utilization of outputs
c) how access of men and women and control over resources would affect implementation and success of the project
d) how will mobility and access to information of men and women and other disadvantaged groups affect implementation and success of the project
e) any other socio-cultural factors regarding roles of men and women in the target communities

Cross cutting issues are not applicable in this study

10. **Cross-cutting Issues (climate change) – *may not be applicable to every project***

a) Briefly describe how the results of this project/study are contributing to mitigation/adaptation to climate change

Cross cutting issues are not applicable in this study

11. **Project Budget:**

Table 8: Budget summary (Full budget in Annex 5)

	Year 1	Year 2	Year 3	Total
1. Salaries & wages - Casual labour				K13,200

2. Operational Costs - Stationary - Communication - Fuel				K2000.00
3. Travel and transport - Local project trips				K1,250.00
4. Capital Equipment - Seeds -Pesticides/Fungicides - Nutrient analysis - Tools spades/knives/forks - Fertilizers				K18, 330.00
Miscellaneous (3%)				K1,043.40
Total				K35,823.40

12. **Resource needs and sources**
a) What are other major resources required for this project (Human Talent, Facilities, major equipment); indicate the availability or access
Human talent – Field Assistants on a 3 months casual basis for three seasons to assist with the trials upkeep and data collection in the three sites (SRC, HRC, MRC).
b) Make suggestions and recommendations for funding sources (NARI, international grants, in-country sources etc.)
NARI Research Grants or international/in country sources

The project proposal has been peer reviewed:
Name of colleagues, name of organisation, position within the organisation: 1. William Sirabis, Soil Scientist, HRC, NARI 2. Clifton Gwabu, Senior Economist, MRC, NARI
Presentation at Centre seminars and discussion (NARI Centre, date of presentation, staff present)
Other forms of review:
Endorsement by the Centre RDC:

Annex 1. Expanded Background/Literature Review (max 3 pages)

Grow Hariap Foliar Fertilizer

The Grow Hariap Foliar Fertilizer (GHFF) is claimed to be 100% organic nutrient source and is produced in Papua New Guinea (PNG). Primary ingredients are suggested to be derived from locally available plants. Through its labeling, nutrient composition contains nitrogen (2.35%), phosphorus (4.44%), potassium (1.75%), magnesium (0.36%), iron (56.7%), manganese (22.3%), copper (22.3%), zinc (15.3), boron (0.0115%), molybdenum (0.0115%) and humic acid (0.68%). It can be used on a range of horticultural and plantation crops species. Additionally, ornamental and tree species can be managed using GHFF.

The liquid fertilizer is recommended to be shaken before mixing and using, and foliar sprayed in the mornings and or late in the afternoons for beneficial results. Dosage will change according to the crops, its nutritional status and weather conditions; rate for plantation crops is 1 liter of GHFF to 200 liters of water (Tep, 2019).

Mr. Christopher Tep is the pioneer in development and production of GHFF. He is one of few early agriculture researchers in PNG. His career with the Department of Agriculture, PNG Cocoa and Coconut Research Institute and PNG Cocoa and Coconut Research Agency (Loop PNG, 2019).

Christopher Tep began working on the fertilizer in 2009. In March 2019, he released the first commercial product with Brian Bell Ltd, where it is currently selling in all its outlets nationwide. It comes in ranges of 500ml, 1L and 20L for semi-commercial prices and larger 200L for larger industrial use. Mr. Tep has a processing facility in Port Moresby. He estimates that more than 5,000 farmers have used it with many positive testimonials coming from farmers using the social media platform Facebook (Loop PNG, 2019).

EcoSan Nutribiotic Fertilizer - Lactobacillus Fertilizer

Singapore Lactobacillus Technology is the producer of the EcoSan Nutribiotic Fertilizer. This fertilizer is uniquely sourced from antibiotic-free poultry manure. It contains micronutrients, macronutrients, and trace elements, the building blocks for plant nutrition and development. EcoSan Nutribiotic is fully fermented - stabilizing the microbial system of the soil (PNG Eden Fertilizers, nd). Additionally, it is claimed that it contains beneficial microbes for both the plants and the soil. PNG Eden Fertilizers in Lae, Morobe Province is its sole distributor.

PNG Eden Fertilizers (n.d) reports that the fertilizers come in both solid and liquid packaging. The solid fertilizer product comes in a range of sizes; 2kg, 5kg and 25kg while the liquid form comes in 1L, 5L, 20L and 200L drums. Nutrient content comprises of nitrogen (4%), phosphorus (2%), potassium (2%), calcium (194.7 mg/L), magnesium (1.4 mg/L), boron (1.6 mg/L), copper (7.1mg/L), zinc (4.8 mg/L), manganese (4.8 mg/L), iron (28.1 mg/L), pH (7.5) and conditioner (11.3 mS/cm) (PNG Eden Fertilizers, n.d). The liquid fertilizer comes in a concentrate state hence the ratio of fertilizer mix differs from seedling to large plantations. The average mixing rate for small plants is 1:100L and 1:150L for plantation crops. The distributors claim that Ecosan Nutribiotic Liquid fertilizer is suitable for a wide range of plants, including seedlings, vegetables, flowers and landscape plants and trees.

Nitrogen Phosphorus Potassium – NPK Granular fertilizer

NPK mineral fertilizers provide the most limited nutrients in needed for optimal plant growth in nearly all agrltural cropping systems. Plants could not survive without one of these essential nutrients. Half of the global population can be attributed to the increased food production resulting from the use of these fertilizers. Soils deficient in these nutrients are supplemented by these fertilizers.

Primary macro-nutrients

Nitrogen is the first important macronutrient in plants. N is vital to chlorophyll for photosynthesis. Plants that have adequate N can have a high photosynthesis process (Mburia, 2016). N is a significant component in amino acids, the building blocks of proteins. N aids in the compounds that allow for energy storage and use. Sources of inorganic N in NPK blends can be urea, urea ammonium (NH4+), nitrate ($NO3^-$) and anyhdrous ammonia. This element is absorbed as ammonium and nitrate in the soil (Hochmuth et al. 2004). Sources of organic N are manure, compost, blood meal and feather meal (Rhoades, 2018).

Phosphorus (P) aids in structural strength, crop quality, seed production and more in plant growth. P encourages root growth and promotes blooming. P is a critical molecular component of a plant's genetic reproduction such that when P is limited in plants, a crucial genetic process like cell division and growth is affected (Zambrosi et al. 2014). Source of inorganic P in NPK blends is from phosphate rocks. It is important to note that all phosphorus comes from phosphate rock. Phosphate rock is first processed into a variety of materials in order to blend and/or granulate it into various fertilizer products. This includes phosphoric acid, Diammonium Phosphate (DAP), Monoammonium Phosphate (MAP), Triple Super Phosphate (TSP) and Single Super Phosphate (SSP) fertilizers. Organic sources of P are manure, compost, bio-solids, blood meal and bone meal (Summers et al. 2014).

Potassium is often referred to as the "quality element" for its contribution to size, shape, color, and taste ('Plant nutrients' 2018). Plants low in potassium is stunted in growth and has lower yields ('Plant nutrients' 2018). Inorganic sources of K in NPK blends are potash/potassium and granite dust while organic sources are manure, compost, bio-solids, and wood ash (Summers et al. 2014).

Granula NPK Production

Components in NPK can be produced separately and "blended" to create the desired nutrient ratio/grade (Feeco, 2021). NPK fertilizer can also be produced to contain the desired nutrient ratio within each granule. Feeco International (2021), a pioneer in the fertilizer industry since 1957 describes their production can be flexible, to allow various additives to be included to create speciality fertilizers**,** or formulations tailored to the needs of a specific region or application. An example of the speciality fertilizer is the *Potato Mix* which contains NPK 10.25.12 + 2.5 MG + 0.2 B (MOP).

Urea (46% N)

Urea (46% N) is the most widely used dry N fertilizer. Once applied to the soil, urea is converted to ammonia which reacts with water to form ammonium within two to three days-faster under warm conditions (Vitosh, 1996). Vistosh (1996) further explains that some volatilization of ammonia can occur when urea is surface applied.

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Annex 2. Logical Framework

	Intervention logic	Objectively verifiable indicators of achievement	Sources and means of verification	Assumptions
Goal	Smallholder farmers' knowledge and choice of appropriate fertilizer inputs improved and safe guarded from the lure of unverified market driven product claims.	*What are the key indicators related to the overall objectives?* Research of fertilizer options on commercial crops in 3 different agro-ecological zones/ regions	*What are the sources of information for these indicators?* 1. Field trials set at NARI SRC, NARI HRC and NARI MRC 2. Documented results of fertilizer impact on crop production and cost profit analysis currently in markets.	1. Completion of evaluation trials in three sites as per schedule. 2. Producer of GHFF accepts and endorses research results.
Strategic Objective	Improved information on the viability of GHFF and conventional fertilizer management practices easily available and disseminated to smallholder horticultural crop producers for best practices to increase crop productivity, quality and profitability.	*Which indicators clearly show that the objective of the project has been achieved?* Replicated field trials conducted and fertilizer effects assessed to determine effects on crop growth and development	*What are the sources of information that exist or can be collected?* 1. Documented results of the viability of GHFF and locally available conventional fertilizers. 2. Documented results of the cost and profitability of the use of GHFF and locally available conventional fertilizers. 3. Increased number of informed farmers on fertilizer choice and suitability.	*Which factors and conditions outside the Beneficiary's responsibility are necessary to achieve that objective? (external conditions)* *Which risks should be taken into consideration?* 1. Delay in experimental set-up. 2. Producer of GHFF will not accept and endorse documented research results if GHFF effects on crop production and profitability are unsatisfactory.

Outputs	*The outputs are envisaged to achieve the strategic objective. (enumerate them)*	*What are the indicators to measure whether and to what extent the project achieves the expected outputs?*	*What are the sources of information for these indicators?*	*What external conditions must be met to obtain the expected outputs on schedule?*
	Output 1: Generate information on GHFF's ability to increase crop productivity and quality.			
	Activity 1.1 Locate trial field	Trial field identified	1. Weekly and quarterly reports	1. Discussion with CM to identify and allocate field for trials in each centre.
	A1.2 Soil testing before establishment of trial	1. Soil sampling conducted 2. Soil samples sent to Prof Kola Chemistry Lab	1. Soil tests report	1. Funding availability 2. Pre-arrangement with Chemistry Lab
	A1.3 Procurement of trial materials & equipment (fertilizers, pesticides, seeds, stationeries)	1. All fertilizers required for the trials procured for each site. 2. All seeds required for the trials procured. 3. All stationeries, materials & equipment for the trial procured.	1. Financial report 2. Acquittals 3. Adequate availability of consumables, materials and equipment for trial activities	1. Funding availability
	A1.4 Land preparation	1. Land clearance 2. Ploughing, harrowing, roto-tilling 3. Plots established 4. Irrigation arranged	1. Weekly Reports 2. Quarterly Reports	1. Pre-arrangement with Centre Managers and Field Supervisors on field preparation requirements. 2. Availability of tractor and implements
	A1.5 Nursery establishment	1. Soil sterilization. 2. Seeds of indicator crops sown in nursery for each site. 3. Crop numbers needed for trials met.	1. Weekly Reports 2. Quarterly Reports	1. Adequate seeds of indicator crops. 2. Materials & equipment availability. 3. Available nursery space.
	A1.6 Trial plots planted	1. Trial design and field plan available for use 2. Establishment of trials in each site	1. Weekly Reports 2. Quarterly Reports	
	A1.7 Data collection and	1. Data collection sheets	1. Records of raw data on key	

	compilation	designed and available for use. 2. Data collection on schedule and compiled.	parameters collected 2. Weekly Reports 3. Quarterly Reports	
	Output 2: Generate information on the cost and profit analysis on the use of GHFF compared to other locally available conventional fertilizers for smallholder farmers' use.			
	A2. 1 Data parameters	1. Data parameters determined.	1. Data collection sheet designed and available for use.	
	A2. 2 Data collection and compilation	3. Data collection on schedule	1. Records of raw data on key parameters collected 2. Weekly Reports 3. Quarterly Reports	1. Timely data collection
	Output 3: Reporting and recommendations of appropriate fertilizer use to increase crop productivity and quality.			
	A3.1 Data analysis and reports	1. Key data parameters compiled and analysed using GenStat	1. Records of raw data on key parameters collected. 2. GenStat ANOVA Output processed and interpreted. 3. Report complete.	
	Output 4: Publications - Research information and dissemination			
	A4. 1 Preparation of information packages	1.Information packages available for dissemination	1. Toktoks, pamphlets or brochures on suitable fertilizers and cost & profit analysis	1. Timely completion of reports
	A4. 2 Preparation of technical reports, newspaper and journal articles	1.Publication of technical reports, Preparation of newspaper and journal articles	1. Published reports 2. Focus and journal articles published	1. Timely completion of reports and articles
	A 4.3 Seminar presentation	1. Final presentation of findings at hand	1. Final seminar presentation for stakeholders	1. Seminar presentation

Annex 3. Project Results Chain

Project Goal and Strategic objective:	Project Goal: Smallholder farmers' knowledge and choice of appropriate and suitable fertilizer inputs improved and safe guarded from the lure of unverified market driven product claims. Project Strategic Objective: Improved information on the viability of GHFF and conventional fertilizer management practices easily available and disseminated to smallholder horticultural crop producers for best practices to increase crop productivity, quality and profitability.
Inputs:	1. Funding Allocation from Research Committee; 2. Technical Research Officers/Personnel, including field staff at SRC, HRC and MRC; 3. Resources – vehicle, materials, facilities & equipment at SRC, HRC and MRC; 4. Land allocated for trials at SRC, HRC and MRC
Outputs	1: Information generated and documented on GHFF's ability to increase crop productivity and quality. 2: Information generated and documented on the cost and profit analysis on the use of GHFF compared to other locally available conventional fertilizers for smallholder farmers' use. 3. Researchers knowledge and skills enhanced on the understanding of the physical, chemical and biological mechanisms that interact in soil-plant ecosystems of fertilizers.
Target Beneficiaries	Immediate beneficiaries: At this stage, there are two groups of immediate beneficiaries: 1. Researchers and extension workers conducting or working with research in nutrients, agrochemicals and crop production will utilize this improved information for the purpose of advice on best practice for increased crop productivity; 2. Producer of the GHFF product. He will be fully informed of his product efficacy on crop production in PNG based on sound scientific data.
	Next beneficiaries: Other beneficiaries are the smallholder producers of commercial horticultural crops from the highlands, low dry land areas, low wetland areas and coastal areas of PNG (all ADD clusters).
Immediate outcomes	1. Availability of sound scientific data on viability and efficacy of GHFF and locally available conventional fertilizers used by smallholder producers of commercial horticultural crops in PNG. 2. Availability of cost and profit analysis information for informed farmer decision on fertilizer use. 3. Researchers enhanced knowledge and skills on fertilizer mechanism used in informed decision on

	best practices in crop production management.
Immediate outcome indicators	1. Documented information on viability of GHFF and locally available conventional fertilizers. 2. Documented information on cost and profitability of the use of GHFF and locally available conventional fertilizers.
Medium-term outcome indicators (medium-term impacts)	1. Increased number of informed farmers on fertilizer choice and suitability when it comes to GHFF and other locally available conventional fertilizers.

Annex 4. Risk Assessment Matrix

Risk Event	P[2]	Impact on the project Re	Responsibility	Mitigation / Management
RISK FACTORS				
Pest & disease occurrence (soil borne and bacterial wilt disease)	5	Destroy data plants which affect trial data	1. Lead scientist in each site	1. Sterilize soil and 2. Identify and select disease free seedlings and site.
Prolong dry period in SRC	3	Irrigation is a concern if there is prolong dry periods in SRC, particularly after seedlings are transplanted into the field. Plant growth and development will be affected.	1. Lead scientist in each site 2. Centre Manager	1. Select trial site at a location with available water source (e.g. water tank or irrigation system). 2. Water can be carted /diverted onto the field trial from existing river water irrigation system to empty drums and watering cans will be used to water seedlings on a daily basis during prolong dry periods.
Flood & frost	3	Occurrence of flooding or frost could damage trials especially at SRC-Laloki and HRC- Aiyura. Entire trial plots will be destroyed.	1. Lead scientist in each site 2. Centre Manager	1. Site selection will be critically assessed taking into account a location that will have minimum or nil impact if flooding occurs in the area. Drains constructed, cleared and maintained during field preparation as precautionary measures. 3. Early warning system in place from National Weather Office to advice on frost occurrence. 4. Have adequate seeds ready for new planting.
Theft	5	Theft of data plants which will affect trial data	1. Lead scientist in each site 2. Centre Manager	1. Security to be vigilant when trials are ready for harvest data.

[2] Key: P=Probability of occurrence (5=Almost Certain, 4=Likely, 3=Possible, 2=Unlikely, 1=Rare

Annex 5. Project Budget

Project Expenses	Purpose/Activity	Unit Cost	Quantity	Cost (K)
1. Salary & Wages				PGK 0.00
Labour costs for field trials in 2 sites (SRC, MRC), 3 seasons (2 years)	Land preparation, transplanting, weeding	PGK 300.00	2	PGK 600.00
	Field Assistants (3months casual contract) for 3 seasons in 2 sites (SRC, MRC) - trial field maintenance, harvesting and data collection	PGK 6,300.00	2	PGK 12,600.00
Sub-Total Section 1.0				**PGK 13,200.00**
2. Experiment Materials/Equipments/Resources				
a. Seeds				
Sweetpotato vines	Indicator crop for MRC for 3 seasons - K0.20/plantlet	PGK 0.20	600	PGK 120.00
Chinese cabbage - commercial variety Pakchoi, Taki, 500g	Indicator crop for SRC for 3 seasons	PGK 100.00	1	PGK 100.00
Capsicum - commercial variety Wonder Bell, Taki, 20mL	Indicator crop for MRC for 3 seasons	PGK 160.00	1	PGK 160.00
Sweet Corn- commercial variety, Taki, 1kg	Indicator crop 2 for SRC for 3 seasons	PGK 150.00	1	PGK 150.00
b. Fertilizers				
NPK (40kg)	Treatment for MRC & SRC	PGK 200.00	2	PGK 400.00
Urea (40kg)	Treatment for SRC	PGK 200.00	2	PGK 400.00
Lactobacilius Eco-san Liquid Fertilizer (Box - 12x 1L)	Treatment for SRC, MRC; K135/1L, 1 box/12 bottles = K1700/box	PGK 1,700.00	2	PGK 3,400.00
Grow Hariap Liquid Fertilizer (Box- 12x 1L Bottles)	Treatment for SRC, MRC; K135/1L, 1 box/12 bottles = K1700/box	PGK 1,700.00	2	PGK 3,400.00
c. Pesticides & fungicides				
Fungicides (1L)	Control of fungal diseases	PGK 150.00	4	PGK 600.00

Pesticides (1L)	Control pests/insects	PGK 150.00	4	PGK 600.00
Knapsack Sprayer (20L)	Spraying (Liquid fertilizer application)	PGK 300.00	4	PGK 1,200.00
d. Packaging				
Net Bags	Packing of tubers & cobs	PGK 3.00	100	PGK 300.00
Vegetable baskets	Harvesting of cabbage and capsicums	PGK 80.00	20	PGK 1,600.00
e. Tools & equipment	Spades, watering cans, pruners, soil augers for 2 sites	PGK 300.00	2	PGK 600.00
f. Nutrient analysis				
Soil test	Routine soil test for 2 sites (SRC, MRC)- before set up & after last harvest - 2 tests/site, therefore 2x 2 sites = 4 tests	PGK 1,200.00	4	PGK 4,800.00
Grow Hariap Foliar Fertilizer nutrient testing	One test for B, Cu, Fe, Mg, Mn, Mo, N, P, k, Zn, Humic Acid	PGK 500.00	1	PGK 500.00
Sub-Total Section 2.0				**PGK 18,330.00**
3.0. Operational Costs				
Stationaries	Field data collection and use for 2 sites (SRC, MRC)	PGK 300.00	2	PGK 600.00
Communication - mobile phones, data for internet	Communication purposes for 2 sites (SRC, MRC)	PGK 200.00	2	PGK 400.00
Land preparation - fuel	Fuel drum (40 Gallon) for 2 sites	PGK 500.00	2	PGK 1,000.00
Sub-Total Section 3.0				**PGK 2,000.00**
4.0. Travelling and Transport Cost				
Local project trips to town (SRC, MRC)	Collect materials/resources	PGK 2.50	500	PGK 1,250.00
Sub-Total Section 4.0				**PGK 1,250.00**
5.0 Total Cost	Sub-Total Section 1.0 + 2.0 + 3.0 + 4.0			**PGK 34,780.00**
7.0 Miscellaneous (3%)				**PGK 1,043.40**
Grand Total Project Cost				**PGK 35,823.40**

Glossary of Terms and Concepts and information on indicators

Activity	Project level: Actions taken or work performed through which inputs, such as funds, technical assistance and other types of resources are mobilized to produce specific outputs
Agricultural Development Domain	Geographical locations where similar agricultural development problems or opportunities are likely to occur and therefore represent areas of broadly similar strategic and investment opportunities or identification of viable sets of livelihood options for the farming communities in such domains
Beneficiaries	The individuals, groups, or organizations, whether targeted or not, that benefit, directly or indirectly, from the development intervention
Goal	the higher-order program or sector objective to which an intervention, such as a project, is intended to contribute; it's a statement of intent
Impact	Positive and negative, primary and secondary long-term effect produced by an intervention, directly or indirectly, intended or unintended. Impact may also be used as being analogous to the result achieved at the 'goal' level. Sometimes referred to as the ultimate outcome. Changes in people lives/wellbeing
Indicator (objectively verifiable indicator)	Indicators are data or signs that allow the objective verification of the achievement of objectives (activities, outputs, strategic objective, goal). The signal progress towards the objectives and are direct or indirect measures of achievement, change or performance.
Intervention	▪ influencing force or act that occurs in order to modify a given state of affairs ▪ the act of making a change in a system
Opportunity/Potential	**Opportunity:** a possibility due to a favourable combination of circumstances **Potential**: The inherent ability or capacity for growth, development, or coming into being
Outcomes	The intended or unintended effects of the outputs from an activity. Outcomes are the events or changes in conditions, institutional arrangements, behaviour or attitudes that will occur as a result of an intervention. **Example:** Changes in peoples behaviour, e.g. participants of the project planning training course have used new skills and knowledge to improve project planning
Output	▪ The products, capital goods and services delivered by a development activity to direct/immediate beneficiaries. ▪ Outputs relate to the *completion* (rather than the conduct) of activities and are the type of result over which managers have a high degree of influence ▪ **Example:** a training course - 20 persons trained in project planning
Problems/Constraints	**Problem:** a state of difficulty that needs to be resolved **Constraint** ▪ The state of being restricted or confined within prescribed bounds; ▪ Element, factor, or subsystem that works as a bottleneck. It restricts an entity, project, or system (such as a manufacturing or decision making process) from achieving its potential (or higher level of output) with reference to its goal. See also theory of constraints.
Productivity	▪ **Physical productivity** is the **quantity** of output produced by one unit of production input in a unit of time ▪ assessed by measuring the production of an agricultural good (e.g. the yield of a food crop) and by estimating its value on the market, thus knowing the potential for profits ▪ In developing country context a productive farm would > provide most of the resources necessary for the farmer's family to live, such as food, fuel, fibre, healing plants, etc. > ensure food security as well as a way to sustain the well-being of a community.

	> produce more goods than required for the community in order to allow trade > Diversity in agricultural production is one key to productivity, as it enables risk management and preserves potentials for adaptation and change
Project	An intervention that consists of a set of planned, interrelated activities designed to achieve defined objectives within a given budget and a specified period of time
Results	A broad term used to refer to the effects of a program, project and/or activities. The terms outputs, outcomes, impact describe more precisely the different type of results at different levels of the logframe hierarchy
Stakeholder	Agencies, organisations, groups or individuals who have a direct or indirect interest in the development intervention or its evaluation
Strategic Objective	= purpose = positive improved situation that a project or program or organisation is accountable for achieving

Criteria to assess indicators.

Indicators must be:

1. Measurable: There must be some practical way to quantify or measure the indicator, either in a quantitative (numerical) way or in a qualitative (descriptive) way.
While quantitative indicators are not necessarily more objective, their numerical precision is conducive to agreement on interpretation of results data, making them usually preferable. However, even when effective quantitative indicators are used, qualitative indicators can supplement them to provide rich information that brings the program results to life.

NO! People's feelings about the elections
YES! Percentage of the population who voted

2. Practical: It must be possible to collect, process and analyze data in time and at reasonable cost. Managers require data that can be collected frequently enough to inform them of progress and influence decisions. Organizations should expect to incur reasonable but not exorbitant costs for obtaining useful information.

NO! Number of targeted population who understand their voting rights (census)
YES! % of targeted population who understand their voting rights (representative sample, through a poll)

3. Reliable: The indicators should be open to independent validation. The values of the indicators should be reliable and comparable over time when collected using the same methods. This is more likely when indicators are measured in a standardized way and with sound sampling procedures.

Data can be measured repeatedly, with precision by different people. While the data that a manager needs in order to make reasonably confident decisions about an intervention do not have to be held to the same rigorous standards research scientists use, all indicators should be able to be measured repeatedly with relative precision by different people.

NO! Number of people receiving quality HIV/AIDS care and support services through workplace programs
YES! Number of people who were tested for HIV at work in the last 12 months

4. Relevant: Indicators must be appropriate for the objective to be measured. They must be attributable (caused by) at least in part to the activities of the intervention to be monitored. The attribution exists when the logic between the levels of objectives is clear and significant.

NO! Agriculture production yield in the country
YES! Agriculture production yield in the district where the project is being implemented

5. Objective: Indicators must be unambiguous about 1) what is being measured and 2) what data are being collected. Indicators must be clearly defined in the intervention's context, and in a manner understood and agreed by all stakeholders. Many indicators use adjectives. Common adjectives in indicators are: successful, adequate, equitable, good, effective, participatory, empowered and well functioning. When using adjectives in indicators, make sure everyone involved agrees on what they mean. Any adjectives used to describe the qualities of an indicator need to be precisely defined. For example:

- what is meant by '**improved service delivery**?'
- an indicator may be '**the area of degraded land**' but what criteria will be used to classify such land?
- for households what is included in '**farm income'** and what in '**non-farm income**?'

NO! Number of expanding and successful parent/teacher associations
YES! Number of parent/teacher associations experiencing an annual increase in membership of at least 5%

6. Useful to management: Information provided by the measure is critical to decision making. Avoid collecting and reporting information that is not used to support program management decisions.

LEVEL OF INSTITUTIONAL CAPACITY

NO! Number of computers; number of staff meetings
YES! Amount by type of resources mobilized
YES! Number by type of critical management systems fully operational

7. Direct: An indicator should measure as closely as possible the result it is intended to measure; e.g., yield of green beans per hectare is a direct measure of the result of efforts to increase coffee production. But number of extension agents trained would not be a direct measure of improved service delivery. Just because people are trained does not necessarily mean they deliver better services. If using a direct measure is not possible, proxy indicators might be appropriate; e.g., sometimes, reliable data on direct measures are not available at a frequency that is useful. Proxy measures are indirect measures linked to the result by one or more assumptions; e.g., in rural areas, it is often difficult to measure income levels directly. Measures such as percentage of village households with roofs (or radios or bicycles) may be a useful, if somewhat rough proxy. The assumption is that, when villagers have higher income, they tend to purchase certain goods. Select proxy indicators for which convincing evidence exists of the link to the result (e.g., research data).

INCREASED VARIETY IN AGRICULTURE PRODUCTION

NO! Number of types of agriculture seeds distributed
YES! Volume of production by type of agricultural product

Formulating indicators

The formulation of the indicator usually includes the following elements that may be combined in one sentence:

- a target or other stakeholder group (who?);
- a descriptive definition of the quality (what?); Q*
- an indication of amount or quantity - percentage, number, ratio (how much?); Q*
- an indication of time (when?); T*
- an indication of location in space (where?).

* QQT = Quality, Quantity, Time