Progress Towards Achieving the Vision of Success of N2Africa

(also addressing Milestone 4.4.1)

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N2Africa

Putting nitrogen fixation to work for smallholder farmers in Africa

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1. Background.

At the half-way stage of the four year N2Africa project it is timely to revisit and evaluate the project's Vision of Success that aims *"To raise average grain legumes yields by 954 kg/ha in four legumes (soybean, common bean, cowpea and groundnut), increase average biological nitrogen fixation (BNF) by 46 kg/ha, and increase average household income by $465, directly benefiting 225,000 households (1,800,000 individuals) in eight countries in sub-Saharan Africa (DRC, Ghana, Kenya, Malawi, Mozambique, Nigeria, Rwanda, Zimbabwe). Indeed, this project links the protein and nitrogen needs of poor African farmers directly to previously inaccessible, massive atmospheric reserves, provides them with new income-generating crop production enterprises, presents a mechanism of renewable soil fertility management and opens the door to the adoption of numerous, profitable accompanying farm technologies and value-adding enterprises".* This milestone was originally scheduled for Month 10 of Year 1, but this target was later proved unrealistic as only three of eight countries (the ECA Region) had completed their first cropping cycle by then, and three others (the Southern Africa Region) had not yet planted their first season. It was then decided to reschedule the Milestone for the end of Year 2 so that its evidence would be based upon at least one and as many as three cropping cycles per region. This Proof of Principle is first presented within the context of the project Vision of Success, then it is related to the project's original and adjusted dissemination and farmer training approaches and then concludes with a short synthesis and lessons learned. Special attention is paid to the quantitative components of the Vision of Success; legume yield increase, increased BNF, expected improvement of household income and number of target households.

2. Raise average grain legumes yields by 954 kg ha^{-1} in four grain legumes.

This yield increase value was based upon the average difference in baseline grain yields and expected yields following improved crop management relating to BNF. These values appear in the Project Implementation Plan and were based upon six grain legumes, including pigeon pea (*Cajanus cajan*) and chickpea (*Cicer arietinum*), two lesser grown legumes that were later dropped from the project proposal. Recalculating these values for the four grain legumes that were retained in the project, bean (*Phaseolus vulgaris*), cowpea (*Vigna unguiculata*), groundnut (*Arachis hypogaea*) and soybean (*Glycine max*), provides a slightly lower average ***grain target of 928 kg ha^{-1}*** (= simple average of 1208 kg ha^{-1} increase for soybean, 1265 kg ha^{-1} increase for bean, 583 kg ha^{-1} increase for cowpea and 655 kg ha^{-1} increase for groundnut (Table 1). One shortcoming in this approach is that it does not adjust for the different numbers of household targeted for each crop (88,393 for soybean, 61,607 for bean, 26,786 for cowpea and 48,214 for groundnut). The recalculated, weighted current average across legumes and households is 904 kg ha^{-1} (not 764 kg), the corresponding weighted ***average yield increase is 1031 kg ha^{-1}***, and this is at least a more mathematically correct overall average. Nonetheless both approaches produce an estimate, and the Proof of Principle rests in yields obtained under farmer conditions and their projected improvement during the project.

Table 1. Originally estimated, Year 2 observed and linearly projected grain yields of the four N2Africa grain legumes.

Grain legume yield	---- Soybean ----		--- Bean ----		---- Cowpea ----		---- Groundnut ----	
	Estimated	Observed	Estimated	Observed	Estimated	Observed	Estimated	Observed
	kg/ha							
Initial	1,007	958	527	658	700	704	1,310	457
Improved management (Y2)	1,611	1,480	1,160	909	992	1,206	1,638	685
Linear trajectory (Y4)	2,215	2,002	1,792	1,160	1,283	1,708	1,965	913
Target improvement	1,208	1,044	1,265	502	583	1,004	655	456

Legume grain yields were compiled by the Objective 2 Legume Agronomy team for each crop's initial conditions and under Year 2 improved management (Table 1). These data were then compared to the estimated yields as they appear in the project Implementation Plan and Vision of Success. A linear trajectory to Year 4 was projected assuming that crop yields continue to improve as management adjustments continue. Observed initial yields were more-or-less in agreement with original estimates except for groundnut, where farm yields were greatly overestimated. ***Overall average estimated and observed initial yields were 886 and 694 kg ha^{-1}, respectively, an overestimate of 27% (calculated from Table 1).*** If it is assumed that grain legume yields will increase in a linear fashion from their initial to their final estimate, then average yields should reach 1350 kg ha^{-1} by the end of Year 2. The observed value was 1070 kg ha^{-1}, only 80% of the original intermediate estimate. If Year 2 yields are projected to Year 4, then the yields are likely to reach an average 1446 kg ha^{-1}. ***This results in an average projected yield improvement of +752 kg ha^{-1}, a value only 81% of the adjusted original estimated grain yield (+928 kg ha^{-1}, see above)***. ***However, when a weighted average is calculated also based upon the number of households targeted for different legumes, that value increases to +1010 kg ha^{-1}, very near the original recalculated estimated weighted average of +1031 kg ha^{-1} (above).*** This closing adjustment results because proportionately more farmers grow soybean than any other crop and because cowpea yield improvement greatly exceeds original estimates. Some deviation between original estimates and Year 2 observations occurred but tended to cancel one another out. These findings were in close agreement, falling within 80%. ***In conclusion, our abilities to close yield gaps as described in the Vision of Success are validated based upon an analysis of yield results compiled during Year 2, and this vision appears sound.*** Finally, one may argue that yield improvement by the end of Year 2 is an incomplete measure compared to what may be achieved by Year 4 because important research findings related to improved crop management have had too little time to take effect at the field level.

3. Increase average biological nitrogen fixation (BNF) by 46 kg ha^{-1}.

Again, this value was derived as a simple average of estimated current and improved BNF based upon findings in the literature, a paucity of which related directly to the project's Action Sites. Removing pigeonpea and cicer results in a simple average of ***34 kg increased N ha^{-1} as BNF*** assuming 60 kg N ha^{-1} for soybean, 31 kg N ha^{-1} for bean, 25 kg N ha^{-1} for cowpea and 18 kg N ha^{-1} for groundnut (Table 2). When weighted by number of households per crop (as above), this increase in BNF N becomes ***39 kg increased N ha^{-1} as BNF***. These revised estimates take into account that cowpea and groundnut are unlikely to respond as much to inoculation because compatible (and competitive) rhizobia already occur in the soil and the higher potential for BNF by pigeonpea and chickpea was dropped from the project in favor of more widely distributed grain legumes. Again, the real test rests in field measurements of BNF under different agricultural. The baseline report quantifying BNF and its contributions is not yet completed (Milestone 1.4.2 due Month 12 Year 1) but samples are presently being analyzed for natural abundance of N^{15}. In the meantime, we have adopted an approach to estimate BNF used in many crop models where *BNF = (legume yield x grain nitrogen content x NDF) / NHI.* Legume yield and grain N are measured and nitrogen derived from fixation (NDF) and N Harvest Index (NHI) are obtained from the literature (Duke 1981; Giller 2001). In this way, BNF may be estimated from grain yield increase (Table 3).

Table 2. Originally estimated, Year 2 observed and linearly projected BNF of the four N2Africa grain legumes.

Biological nitrogen	---- Soybean ----		--- Bean ----		---- Cowpea ----		---- Groundnut ----	
fixation	Estimated	Observed	Estimated	Observed	Estimated	Observed	Estimated	Observed
	----------- kg N/ha -----------							
Initial	50	63	13	13	30	38	35	21
Improved management (Y2)	80	97	29	22	43	68	44	33
Linear trajectory (Y4)	110	131	44	31	55	98	53	45
Target improvement	60	68	31	18	25	60	18	24

Table 3. Coefficients for calculating BNF based upon on grain legume yield.

coefficient	soybean	bean	cowpea	groundnut
seed N	0.057	0.035	0.037	0.035
NDF	0.75	0.45	0.68	0.65
NHI	0.65	0.70	0.47	0.50

An analysis was performed for biological nitrogen fixation similar to that of grain yield. Observed initial BNF were more-or-less in agreement with original estimates except for groundnut, where disagreement resulted from greatly overestimated yield. ***Overall average estimated and observed initial rates of BNF were 32 and 34 kg N ha^{-1}, respectively, an underestimate of only 5% (calculated from Table 2).*** If it is assumed that BNF increases in a linear fashion from their initial to their final estimate, then average overall BNF rates should reach 49 kg N ha^{-1} by the end of Year 2. The observed value was 55 kg N ha^{-1}, exceeding estimates by 13%. If Year 2 yield are projected to Year 4, then the BNF is likely to reach an average 76 kg N ha^{-1}. ***This results in an average projected BNF increase of +43 kg N ha^{-1}, a value 93% of the estimate appearing in the Vision of Success. However, when a weighted average is calculated also based upon the number of households targeted for different legumes that value increases to +58 kg N ha^{-1}, exceeding that estimate by over 25%.*** This closing adjustment results because proportionately more farmers within N2Africa grow soybean than any other crop and because BNF by cowpea exceed original estimates. ***In conclusion but based upon an incomplete data set, it is likely that the project will exceed its targets for BNF in smallholder legume cultivation, especially when calculated on the basis of weighted averages. Indeed, this vision appears conservative.*** We note that the analysis of BNF is based upon calculated values and these must soon be compared to measured values as required under Milestone 1.4.2. Finally, it is possible that BNF increases in a greater than linear trajectory as improved inoculation delivery systems and more effective rhizobia are identified through research findings by the Objective 3 Rhizobiology team.

4. Increase average household income by $465.

This value is based upon the simple overall average grain legume yield (954 kg ha^{-1}) and an average price for all four legumes ($0.50 per kg). This approach is rather simplistic as it assumes that all participating farm households cultivate 1.0 ha during the year and that all are engaged with markets (in contrast to Milestone 4.4.3 targeting 50% market participation). Alternatively, the average area of expanded legume cultivation per household of 0.36 ha per season and the proportion of households operating in bimodal precipitation (33% with two seasons per year), a more realistic estimated ***proposal target is +$223 per household per year***. To test this target, it is useful to have yield increases and prices for different legumes, and a firmer estimate of land area committed to legume cultivation among participating farmers by the project's end.

A preliminary analysis of potential household income generation suggests that the reduced estimate (+$226 per year) is readily achievable for soybean and cowpea (Table 4). However, the target may prove difficult to achieve for bean and groundnut unless both yields are improved and farm production areas are increased. This analysis must be regarded as preliminary as it is based upon an incomplete set of yield data and is extremely aggregated in terms of commodity price and average field area per household. Nor does it consider areas with two cropping seasons per year. ***Nonetheless, it reinforces the concern that the original estimate of $465 increased household income was based upon an incomplete set of assumptions and will likely prove to be less as the project progresses. This vision will likely prove excessively optimistic.*** However, value adding processing is not considered in this analysis and may prove means to raise average household incomes pending findings from Milestone 4.3.4 where "*at least half of the farming communities engaged in the project are linked to legume processing initiatives*" during Year 3.

Table 4. Projected household income generation from the project's four grain legume crops.

Crop	Soybean	Bean	Cowpea	Groundnut	Average/ (total)
Target households	88393	61607	26786	48214	(225,000)
Final cropping area (ha)	34,195	19,800	15,000	8,000	(76,995)
Area per household (ha)	0.39	0.32	0.56	0.17	0.36
Increased crop yield (kg)	481	161	562	75	320
Commodity price ($/kg)	0.50	0.60	0.50	0.60	0.55
Increased crop value ($/ha)	240	96	281	45	166

5. Directly benefit 225,000 households (1,800,000 individuals) in eight countries in sub-Saharan Africa.

The number of target farm households (225,000) participating in the project result from assigning 75,000 households in each of three regions (East and Central Africa, Southern Africa and West Africa). It was clear that the N2Africa Project is intended to engage in applied and developmental research that impacts upon the lives of Africa's rural poor, and this target was regarded at the time as ambitious but achievable. In the project document, an incremental schedule of new farmer recruitment was developed that engaged 18,000 households, 24,000 households, 51,000 households and 132,000 households in Years 1 through 4, respectively (Table 5). The total number of persons (1.8 million) is based upon the assumption of 8 persons per household. To a large extent, the budget developed for Objective 4 was built around these households and failure to meet them suggests that our activities were incorrectly planned.

Table 5. Original and revised dissemination targets over the project’s four years.

Year	Original Dissemination Targets		------------- Revised Targets[1] ------------				
	per year	cumulative	cumulative	WA	SA	Kenya	CA
1	18000	18000	11000	3000	0	3000	1000
2	24000	42000	56500	13000	2000	13000	5750
3	51000	93000	159834	37500	9000	29000	14417
4	132000	225000	225000	37500	25000	37500	18750

[1] WA = both Ghana and Nigeria, SA = Malawi, Mozambique and Zimbabwe and CA = DR Congo and Rwanda.

During Year 1 it became obvious that the schedule for farmer participation over time, but not the total number of households, required adjustments. Adequate extension mechanisms with expertise in BNF were in place in Ghana, Kenya, Nigeria and Zimbabwe; but less so in DR Congo, Malawi and Rwanda. Owing to the scheduling of the project, there was insufficient time to launch field campaigns in Southern Africa during Year 1. Also, concern existed over the large proportion of households targeted for Year 4 alone (59%). These realities led to a revised schedule for engaging farmers based upon country capacities and growing season characteristics that still totaled 225,000 households over four years (Table 5). Note that by the end of Year 2, the project was expected to engage 56,500 households but actually reached 65,322, exceeding revised Year 2 expectations by 16% (Table 6). Allowing some leeway between countries, only DR Congo has failed to reach its farmer targets, in large part because of a shortage of seeds. In Southern Africa, all three countries have exceeded targets despite their late start. ***This vision appears conservative assuming a similar trajectory (+32% by the end of four years), the project will directly engage about 297,000 households through Year 4.*** From this assessment it is clear that a realistic number of farm households were targeted by the project.

Table 6. Cumulative households impacted over the project's first two years.

Country	Target	Realized	Achieved
Ghana	13000	11160	86%
Nigeria	13000	13980	108%
Malawi	2000	3432	172%
Mozambique	2000	8687	434%
Zimbabwe	2000	2215	111%
DR Congo	5750	3806	66%
Kenya	13000	16722	129%
Rwanda	5750	5320	93%
Total	56500	65322	116%

Success in reaching household targets is in large part related to meeting Milestones 4.3.1 and 4.3.2 in sequence. Milestone 4.3.1 requires that "*sufficient legume seed is acquired ... for initial dissemination in the various impact zones*" and Milestone 4.3.2 requires that "*at least half of the farming communities engaged in the project are actively producing legume seed for local distribution*". Keeping in mind that the best legume varieties identified by the Tropical Legumes II project are not yet available through commercial seed companies, it is necessary to foster community-based seed production and offer incentives (e.g. continued project participation) for retaining seed for the following season. By the beginning of Year 3, more than 100 tons of legume seed are required to meet project dissemination needs, and failure to assist cooperators to multiply, process and bulk these seeds in a timely manner jeopardizes project growth. In other words, we can readily purchase inoculants and fertilizers necessary to meet project targets, but seed must arise from cooperators' rolling stock.

6. Examination of Dissemination and Extension Approaches.

Dissemination relied upon a stepwise process of farmer training where a cadre of Master Trainers from all eight countries participated in a one week workshop in Year 1 (Milestone 5.3.1) and were then expected to train 40 Lead Farmers (or Master Farmers) in each country, resulting in 320 trainers of farmers at the grassroots level (Milestone 5.3.2). These trainers were then expected to each train 66 farmers twice (132 total) resulting in about 42,000 farmers (Milestone 5.4.1), the original target through Year 2 (see Table 5). The actual number of Lead Farmers greatly exceeds this target more than five-fold with 1788 trained to date (Table 7). Farmer Training at the grassroots also exceeds expectation by 19% with 67,109 trainees through Year 2.

Farmer training in BNF required the development of instructional materials. Master Trainers were provided with a 188 page manual consisting of 10 electronic training modules. Lead Farmers received a 24 page booklet (later translated into six languages) focusing on more practical aspects of BNF and grain legume enterprise; and detailed field protocols and data report forms every growing season. Individual farmers were given one-page farmer guidelines and field instructions. A sub-sample of 2400 farmers was provided with a field booklet that was completed over the season and returned to the M&E team. This effort was supported by the anticipated need for sufficient funds for the publication of extension materials, first held by the Objective 5 Capacity Building team but later distributed directly to individual country budgets.

A strength in dissemination approach is its flexibility to work with different types partners including Ministries of Agriculture and their local extension agents, international NGOs and their country chapters, national NGOs and community-based organizations, and perhaps most importantly local farmer associations. Clearly, different training strategies operate in different countries. In Nigeria, Malawi, Mozambique and Zimbabwe a large number of trainers were commissioned resulting in closer contact between trainers and trainees (training ratios of 19:1 to 43:1). The project relies heavily on agricultural extension agents in Ghana

Table 7. Training of Lead Farmers (Master Farmers), and their subsequent grassroots training, the training ratio and initial training of agro-dealers through Year 2.

Country	--- Farmer Training ---		Training	Agro-dealers
	Lead Farmers	Grassroots	ratio	trained
Ghana	60	10800	180:1	5
Nigeria	519	11594	22:1	0
Malawi	525	10500	19:1	13
Mozambique	271	11637	43:1	0
Zimbabwe	240	6588	27:1	0
DR Congo	29	3025	104:1	0
Kenya	62	10515	169:1	7
Rwanda	127	2450	19:1	0
Total/(average)	1788	67109	(94:1)	25
Expected	320	56500	132:1	80
Achieved	559%	119%	140%	31%

and Nigeria, and would not be permitted to operate without doing so. In Zimbabwe, a mixture of 50 extension staff and 190 farmers were trained and then instructed 6588 households on BNF technologies through 40 different training events during 2010 and 2011. In East and Central Africa, fewer Master Farmers are required because they conduct training during each of two growing seasons. No country followed the stepwise training exactly as planned, resulting in trainee to trainer ratios considerably greater and less than originally intended and the overall training process appears to be effective and better adjusted to local conditions and opportunities. It appears, however, that the planned trainer to trainee ratio of 132:1 was too great and reduced to 94:1 out of necessity as four country teams in Nigeria and Southern Africa trained many more grassroots trainers than first planned.

Within the project, farmer training is intended to backstop large-scale dissemination campaigns advancing BNF technologies (Milestone 4.4.2). These campaigns required the rapid development and regular refinement of dissemination tools in collaboration with project researchers. Milestone 4.2.1 requires "*at least 1 dissemination tool for each action site related to legume and inoculant use is produced per impact zone (country Action Sites)*" in Years 2 to 4, resulting in at least eight different tools by the end of Year 2. It quickly became obvious that dissemination tools and dissemination campaigns are necessarily linked, and the first of these tools need be developed in Year 1 and formalized into field protocols in support of field campaigns targeting 11,000 households during Year 1 (Table 8). Also, as dissemination tools took shape as management packages for different target legumes and growing conditions, their number correspondingly increased. So too when additional tools were required to better process seed (Milestone 4.3.2) and market grain (Milestone 4.3.3). As of the end of Year 2, a total of 39 dissemination tools (an average 4.9 per country) were developed in support of dissemination campaigns. These tools combined expertise and products relating to rhizobium inoculation, phosphate fertilization, selection of fertilizer blends, intercropping or rotation systems, climbing bean staking systems, micronutrient addition, starter N, soil liming, rock phosphate addition, seed bed establishment, organic fertilizers, gypsum (for groundnut pod set) and disease management (particularly for soybean rust control). These BNF technologies and grain legume managements are described in fuller detail within the recently released N2Africa Year 2 Report. One weakness is that these dissemination tools are not being shared well between countries and regions, in part because of their site and variety specific nature.

This Proof of Principle also considers the ability of different countries to meet the project's ambitious dissemination schedule. This schedule extends beyond the number of farmers trained and "reached" (Table 6) but also the abilities of communities to produce improved varieties of grain legumes introduced through the project (Milestone 4.3.2) and their linkage to markets (Milestone 4.3.3) (Table 8). By Year 2, the project made considerable advance in these two areas but lagged slightly behind its 50% targets. In terms of seed production, this figure (44%) is an underestimate as it only includes those communities that have formalized seed production and distribution. Keep in mind that participating organizations are often required to become self-sufficient in legume seed because their are no commercial suppliers available, and in this way any organization that continues with N2Africa is producing seed.

Table 8. Households impacted, dissemination tools employed and communities connected to seed supplies and markets by Year 2.

country	Dissemination tools employed	Connected to … seeds	markets
		------ % ------	
Ghana	3	12	na
Nigeria	5	41	all
Malawi	8	57	57
Mozambique	5	60	80
Zimbabwe	5	57	42
DR Congo	5	25	21
Kenya	4	76	36
Rwanda	4	25	25
Average	4.9	44%	44%
Expected	2	50%	50%
MS reference	MS 4.2.1	MS 4.3.2	MS 4.3.3

One decentralized mechanism of seed production that emerged is the two-for-one arrangement whereby farmers receiving seed for the first time repay their local organization twice that amount at season's end. This arrangement works well, unless crops are stricken by drought or pests, but is not particularly conducive to record keeping as these seeds are simply transferred within the most localized setting. In Kenya, we facilitate these grassroots efforts with labeled bags for seed and seed treatment chemicals, and by matching seed production with recommended rhizobial inoculants. The Milestone 4.3.3 report is "Linking Legume Farmers to Markets" and we refer readers to that document for details on individual country developments. Two important points are that most the successful linkage to markets often results as a carryover from past project's momentum and requires that farmers produce sufficient crop surpluses. Farmer groups introduced to new crops, particularly soybean, were least able to link to markets within only two years. Another emergent trend is the interaction between seed production and market linkages where the same buyers identified through the project seek to purchase seed stocks needed by the project the following season, suggesting that rolling project seed stocks warrant careful coordination or risk being lost to eager buyers (and willing collaborator sellers) of our own design.

One extension activity underachieved by Year 2 was the training of agro-dealers (Table 7). Milestone 5.4.3 requires that "*at least 30 agro-dealers in each region are trained in accessing, managing and distributing information on inoculant use each year*" by Month 10 of Years 2, 3 & 4. This recurrent milestone was only 31% achieved by Year 2 with no activities initiated in five of eight countries (also see Year 2 Report, Table 17). Reasons for this vary, and we refer readers to the recently issued Milestone 5.4.3 report, but basically there was no obvious budget item supporting agro-dealer training and there was no arrangements made for sharing of tested training materials between countries. This shortcoming is now being addressed at the highest levels of project leadership and we await better performance during Year 3.

Project outreach also requires that extension, media and nutrition events be conducted and that gender participation be equitable. Milestone 4.4.3 requires that "*at least 3 extension events be organized per season per country*" and this goal is greatly exceeded with nearly 11 events being held per country per year (Table 9). Most of these events are farmer field days.

Table 9. Extension, media and nutritional events conducted through Year 2 and the participation of women in rural activities.

Country	Extension events		Media	Women's	Nutrition
	per year	per season	events	participation	events
Ghana	25	25	3	33%	1
Nigeria[1]	11	11	8	"all"	6
Malawi	12	12	4	51%	12
Mozambique	4	4	4	30%	24
Zimbabwe	18	18	0	62%	3
DR Congo	40	20	11	60%	2
Kenya	52	26	13	51%	4
Rwanda	13	7	3	61%	1
Total/Average	175	123	70	50% (Avg)	53
Achievement	265%	255%	96%	99%	166%

[1] Nigerian radio and television media outlets that conducted approximately 41 broadcasts relating to the project.

Milestone 4.4.4 assigns "*at least 3 mass media events (e.g., radio programs, video documentaries) organized per region per year*". Overall, this goal is nearly met (96%), although efforts in some countries (DR Congo, Kenya and Nigeria) greatly exceed others (Ghana, Rwanda and Zimbabwe). Most media events take the form of local radio shows and local newspaper articles, and this format appears to reach the right audience for little or no money. Otherwise, the skill set and funds necessary for organizing a more sophisticated media event, such as a press conference or video documentary, are quite different from organizing a farmer field day. Once again, no funds are specifically earmarked for these media events. At the same time, project achievements are newsworthy in themselves, and country teams should make an effort to access local news coverage as was done so effectively in Nigeria (see Table 9 footnote).

Milestone 4.5.3 requires "*at least 2 special events on the role of legumes in household nutrition and value-added processing conducted per country*" every year. Specific approaches to this milestone task within different countries are reported in detail the Year 2 report. Overall, this milestone is "exceeded" by 66% owing to a large number of events being conducted in some countries (Malawi, Mozambique and Nigeria) while other countries have fallen behind schedule (DR Congo, Ghana, Rwanda and Zimbabwe). This skewed performance is again the result of failure to share project resources between countries. This issue should be raised in the next Interim Assessment Workshop so that those countries making the least progress benefit more from the successful experiences of others. Also, meeting this milestone target requires only that special exhibits be established within larger farmer field days, or that cooking contests be held following guidelines that were provided to Master Trainers, so country teams are advised to better consider this milestone when organizing their next season's dissemination campaign. For example, an 3 m x 3 m exhibition pavilion costing about $200 was developed to display nutrition information and demonstrate grain legume processing. It was exchanged among cooperators' field days in Kenya and operated by different women Master Farmers (Photograph 1). Incidentally, these exhibits tend to attract the largest and most enthusiastic audiences during field days, especially when food samples are being offered.

Photograph 1. A traveling exhibit on grain legume nutrition and processing developed in Kenya.

Milestone 4.5.2 requires "*the involvement of women in at least 50% of all farmer-related activities*" and be reported in Years 2, 3 and 4. The donor was emphatic from the project's onset that this is no minor task and that outreach activity must actively promote the empowerment of rural women, and this target was met (Table 9). In some case, the project took an active role in requiring that half the Master Trainers and Lead Farmers be women, and that women's groups be included among grassroots partners. In other cases, women's participation simply resulted from the high level of women-headed households, or through the association of grain legumes as "women's crops". In yet others, where women's roles are more strictly governed within male-dominated cultures, women's opportunities became a very sensitive issue when pushed beyond certain limits. Among agro-dealers, it proved difficult to meet the 50% quota among workshop trainees. Nonetheless, be assured that N2Africa is systematically offering opportunities to rural women and not only seeking their full participation but also their leadership.

7. Linking the protein and nitrogen needs of poor African farmers directly to previously inaccessible, massive atmospheric reserves.

This vision is basically a restatement of the project's full title "*Putting Nitrogen Fixation to Work for Smallholder Farmers in Africa*". That large amounts of nitrogen reside in the atmosphere and that these reserves are accessible through BNF are given. That symbiotic legumes, including bean, cowpea, groundnut and soybean, occupy a special place in smallholders' farming systems is also accepted, but so too is the more intensified management needs of legumes compared to many cereal and root crops. The challenge rests in linking protein and nitrogen needs to poor farmers growing too few legumes and/or managing them insufficiently. One issue is whether or not it is important that farmers completely understand symbiotic BNF, or that they merely develop a working knowledge of BNF technologies. It is very important that farmers recognize that grain legumes do not require addition of nitrogen-bearing fertilizers, and offer some residual benefits related to N recycling best realized through crop rotation. In our current training strategy, the theoretical understanding of BNF is provided to the project's Lead Farmers, who are then able to respond to the queries of participating farmers being exposed to more practical BNF technologies and grain legume managements. The project has developed a simplified nitrogen cycle as it relates to small-scale farmers and presented in illustrated form in several local languages (Figure 1). In this way, the project provides new income-generating crop production enterprises, presents opportunities for renewable soil fertility management and opens the door to the adoption of numerous, profitable accompanying farm technologies and value-adding enterprises. ***Widespread promotion of BNF technologies and grain legumes by N2Africa implicitly links smallholders' nitrogen needs to atmospheric reserves, suggesting that this vision is sound***. The level of farmer adoption and magnitude of these benefits are yet to be quantified.

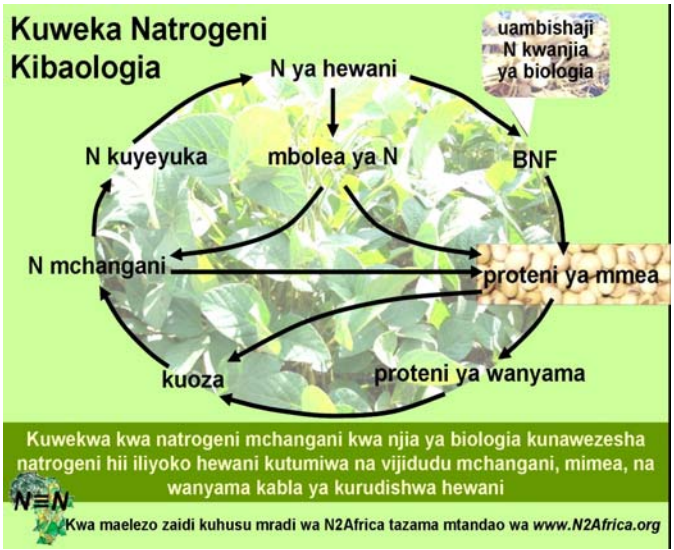

Figure 1. The nitrogen cycle explained in Kiswahili as a means to promote farmer understanding of BNF. Similar diagrams were prepared in English, French, Hausa, Rwandese and Shona.

8. Providing new income-generating crop production enterprises.

The project is built upon the assumption that increased BNF in smallholder systems requires that legume cultivation be profitable. Milestone 1.3.3 requires a "*complete market analysis for inoculum in representative areas of the three hubs ... including cost/benefit analysis at smallholder level ...*", but this milestone report is under development in large part because of a paucity of information on the costs and returns of grain legume production under smallholder conditions. The Action Site in Kenya offers perhaps the best opportunity to analyze these benefits and costs because 1) it relies upon a locally-produced, fully-commercialized inoculant (BIOFIX) and has established close working relations with its manufacturer, 2) west Kenya has two growing seasons per year allowing for more rapid generation of production and economic data, and 3) farmers working with N2Africa have strong access to soybean markets so that costs and commodity prices are readily determined (Woomer 2007). For these reasons, this report only offers information on the profitability of soybean production in west Kenya, and information on other legumes and countries will be contained in the upcoming, more detailed Milestone 1.3.3 report.

Table 10. Estimated production costs of soybean in west Kenya during the 2011 long rains growing season.

management	seed & inoculant	fertilizer & fungicide	labor	bagging	total
SB19 spraying only	$40	$46	$87	$5	$178
SB19 SSP no BIOFIX	$40	$107	$90	$6	$243
SB19 SSP w/BIOFIX	$62	$107	$91	$8	$268
SB19 Sympal w/BIOFIX	$62	$119	$93	$11	$285

Returns to smallholder's use of BIOFIX inoculant on soybean were calculated based upon yield and price information during the 2011 long rains, comparing four different managements involving inoculation and fertilizers with all plots sprayed with fungicide to control soybean rust. Total production costs ranged between $178 to $285 per ha including labor (Table 10). Labor costs were estimated by assigning time and wage for different field tasks in consultation with farm association leaders. Soybean yields ranged between 758 and 1680 kg per ha depending on management resulting in net returns of $266 to $699 per ha (Table 11). The best returns were obtained from applying BIOFIX inoculants and Sympal blended fertilizer, offering a benefit:cost ratio of 3.5. Note that Table 11 also contains information on total days of labor requirement (33 to 39 days per ha), the grain to seed weight ratio (13 to 28 seeds per seed) and the Agronomic Efficiency of fertilizer use (2.1 to 9.2 kg grain per kg fertilizer) Incidentally, the Sympal blend developed by N2Africa in Kenya contains P, K, Mg, Ca and S, consistently outperforms phosphate fertilizers and was subsequently commercialized by MEA Fertilizers based upon project findings.

Table 11. Grain yield and economic returns to soybean production in west Kenya during the 2011 long rains growing season (based on 26 farms).

management	SB19 yield kg ha^{-1}	gross return	net return	benefit: cost ratio	labor days per ha	grain: seed ratio	AE fertilizer ratio
		------ $ ha^{-1} -----					
SB19 spraying only	758	444	266	2.5	33	13	na
SB19 SSP no BIOFIX	970	568	325	2.3	36	16	2.1
SB19 SSP w/BIOFIX	1310	767	499	2.9	37	22	5.5
SB19 Sympal w/BIOFIX	1680	983	699	3.5	39	28	9.2

Table 12. Costs and returns of maize-bean intercrops and soybean monocrop in west Kenya during the long and short rains growing seasons.

management	season	total cost	gross return	net return	benefit: cost ratio	labor days per ha
	------------------------	$ ha^{-1}	------------------------			
maize/bean intercrop	LR	241	1153	913	4.8	41
soybean monocrop	LR	285	983	699	3.5	39
maize/bean intercrop	SR	258	615	357	2.4	39
soybean monocrop	SR	247	912	666	3.7	34

Profitability of a grain legume management is important, but not the only criterion for adoption because its performance must be weighed against other farm opportunities. In the case of west Kenya, the most widespread cropping system is maize-bean intercropping (Table 12). A preliminary analysis suggests that maize-bean intercrops and soybean monocrops require similar levels of investment but opportunity varies with growing season. During the long rains, maize-bean intercropping is more profitable than soybean production but the situation is reversed in the short rains. Soybean returns are relatively constant between growing seasons and require slightly less labor than maize-bean intercropping. Note that these findings are obtained from separate sets of farms and do not include the benefits of crop rotation, but suggest that a maize-soybean rotation is more advantageous when practiced over the long and short rains, respectively. These findings offer a narrow cross-section of opportunities from grain legume enterprises being promoted by the N2Africa Project but nonetheless offer promising economic returns. ***This vision appears sound for soybean in Kenya but must be more systematically documented with other crops and in other countries.*** Consequently, all country teams should evaluate on farm trials from both agronomic and economic perspectives during the final two years of the project.

9. Presenting a mechanism of renewable soil fertility management.

This vision is based upon the likelihood that grain legume enterprise will result in a net nitrogen balance where BNF exceeds N off-take as harvest. Preliminary evidence suggests that this is indeed the case for all legumes except bean (Table 13). These data are calculated from crop yield (Table 1), estimated BNF (Table 2) and crop growth coefficients (Table 3) where N removal = yield x seed N and crop residue = (yield/HI) - yield. These balances are contained in the aboveground crop residues and are subject to management as mulches, livestock feed or soil inputs. The estimate does not include nitrogen contained in the roots and senescent nodules that is released into the soil through decomposition. Crops are often uprooted at harvest, allowing for management of the uppermost roots and nodules as well but this is not considered within Table 13. At first approximation, average BNF is 73 kg N per ha, most (or in the case of bean all) of which is removed as harvest, leaving between 10 to 28 kg N per ha in aboveground biomass. This residual N is worth between $14 and $40 to the cropping systems in terms of fertilizer N substitution.

Table 13. Estimates of total BNF, nitrogen balance, crop residues and residue C:N ratio for four grain legumes.

parameter	soybean	bean	cowpea	groundnut	average
total BNF (kg N ha^{-1})	132	26	91	42	73
N removal (kg N ha^{-1})	114	41	63	32	62
N balance (kg N ha^{-1})	18	-15	28	10	10
crop residue (kg ha^{-1})	1078	497	1926	913	1104

The management of this residual nitrogen takes different forms. Most of the leaves of soybean and bean senesce and fall as surface mulch, to be incorporated through tillage, leaving only stems as products of harvest residues. Stems and leaves of groundnut remain green until harvest and serve as excellent livestock feed. Cowpea and climbing bean are intermediate, depending on variety. Livestock manures are then commonly recycled into the soil based upon farmers' perceived opportunity and not necessarily to the same field from which crop residues were obtained. The most practical means of utilizing this residual BNF is through rotation with annual field crops, but other strategies include producing compost for horticulture or mulching the bases of tree crops (Sanginga and Woomer 2009). As of Year 2, too few cropping seasons have passed to examine the benefits of crop rotation and other residue management strategies, but this will be examined in greater detail by the Legume Agronomy team over the next two years. ***Preliminary evidence suggests that this vision is sound for all crops except bean and that the most likely, but not only, mechanisms for renewable soil management is through cereal-legume rotation.***

10. Opening the door to the adoption of numerous, profitable accompanying farm technologies and value-adding enterprises.

Several accompanying farm technologies, embodied in commercially available products, are being adopted by farmers as they gain confidence and experience in more intensified grain legume production. The most obvious is the use of rhizobial inoculants, both the two brands profitably manufactured in Africa by MEA Fertilizers Ltd, in Kenya (described in greater detail below) and by SPRL in Zimbabwe, and the three brands being imported from Argentina, Spain and the UK. Other accompanying technologies include specially blended fertilizers containing phosphate, potassium, magnesium, sulfur and micronutrients, but not nitrogen; and wider use of pesticides, particularly fungicide for soybean rust and insecticide (including botanical products) for pests of bean and cowpea. Linking with agro-dealer networks assures that these technologies are commercially available, including bio-control products. Pesticide management technologies also include more integrated approaches based on locally available materials and indigenous knowledge. Ultimately, we seek to see the improved legume varieties identified through the project marketed by seed companies and their products sold alongside inoculants, fertilizer blends, etc.

10.1 Profitability of legume inoculants.

BIOFIX inoculant is manufactured by MEA Fertilizers Ltd. at its factory in Nakuru, Kenya. Production began in 2010 after licensing the process and brand from the University of Nairobi MIRCEN. Briefly, broth cultures are raised in five liter flasks containing YMB aerated with filtered pumps. Liquid cultures are mixed with finely-ground, sterilized "filter mud" obtained from a sugar processing factory and cured at room temperature for two weeks. BIOFIX offers a full range of products for bean, soybean, pea, alfalfa and other economic legumes in packets of 10, 20, 50 and 100 grams, all marketed with the appropriate quantity of powdered gum arabic adhesive. Quality control services are provided by the University of Nairobi as per licensing agreement and the resulting population of rhizobia averages only 410 million cells per gram (CV = 34%). This population is somewhat below the target of $>10^9$ cells per gram, presumably because of the silt content of the carrier material. Nonetheless, this corresponds to about 533 million rhizobia per seed when a 100 g packet is applied to 10 kg of soybean seed (about 0.13 g per seed). Approximately 400,000 packets of BIOFIX were marketed during 2011.

A breakdown of production costs and profits of BIOFIX, based upon a 100 g packet, is presented in Table 14 and Figure 2. Total production and marketing costs are estimated to be $0.72. At a sales price of $1.34 per 100 g this allows a manufacturers profit of $0.62 per unit. The suggested retail price is $2.50 per packet, resulting in a retailer profit of $1.16. When asked for details on production costs and returns, MEA Fertilizer only offered information on their wholesale price and suggested retail price (and did not respond to further queries for more detailed information). Consequently, the production costs of BIOFIX were calculated based upon familiarity with MEA's production process and operations. If we assume that the average size of packets marketed was 50 g, and that profits are proportionate to packet size, then MEA produced about $268,000 of inoculants in 2011. MEA's target production in 2012 is one million packets.

Table 14. Breakdown of production costs and profits of inoculant based upon BIOFIX offered to N2Africa for $1.34 per 100 g packet.

Item	$ per 100 g packet
Retailer mark up	1.16
Manufacturer profit	0.62
Labor and quality control	0.22
Marketing and accounting	0.13
Equipment depreciation	0.10
Monthly facilities	0.08
Broth production	0.07
Packaging	0.07
Carrier preparation	0.05
Total	**2.50**

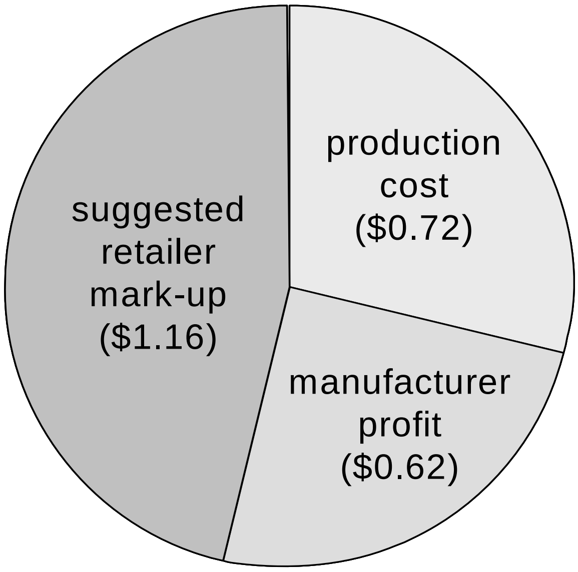

Figure 2. Estimated manufacturing costs of BIOFIX inoculant, manufacturer's target profit and suggested retail mark-up in Kenya.

10.2 Value-adding enterprise.

One unexpected benefit from the project is the role of youth (younger farmers) in promoting market-oriented farm planning, providing local services in land preparation, pest and disease management, post-harvest processing and operating marketing collection points. In this way, crop management itself becomes a value-added enterprise as these entry points often require tools not readily available to most smallholder farmers and occur along the entire agricultural value chain. This suite of activities provide several opportunities to youth themselves but also provide even larger benefits to their farming communities as a whole. This benefit to the more energetic and enterprising community members was not particularly foreseen but is emerging as a project strength and should be encouraged whenever possible.

The scope of value addition to grain legumes is also emerging. These options range from harvesting early to recover higher-value fresh pods and seeds, local processing of harvests into preferred foods, and producing seeds for sale at higher prices. The most options are available for soybean, which is widely regarded more as an industrial rather than a food crop, with processing options ranging from local cottage enterprise through advanced industrial manufacturing. Two important attributes is that soybeans are high in both oil and protein, and that when processing soybean, different fractions can be used for alternative, value-adding purposes. An example is soybean pressed for either oil or soymilk, and then the press cake blended into high-quality animal feed. Similar opportunity exists for groundnut pressed for oil, but beans and cowpeas tend to be utilized as whole grains. Local processing of soymilk and industrial manufacturing of textured vegetable protein are highlighted in the contrasting examples that follow.

Table 15. A simple five-step procedure for local production of soymilk.

Step	Process	Cost/Value
Step 1: Soak	Wash and soak 1 kg of soybean in 2 l clean water for 4 to 6 hours	- $0.50
Step 2: Mince	Pass 3 kg soaked soybean through mincer, add 5 liters clean water, mix	- $0.24
Step 3: Press	Transfer mince to clean cloth and press between two heavy pots, drain	- $0.08
Step 4: Boil	Filter soymilk, boil for 5 minutes, recover 2 kg press cake for grit or animal feed	+ $0.37
Step 5: Package	Cool and place 6 liters of soymilk in clean container or add tea and sugar and market (consume) as "African sweet tea".	+ $3.40

10.3 Value-adding enterprise: local soymilk production.

Soymilk is being produced at the grassroots level following a simple five-step procedure using apparatus costing only $55. Briefly, soybeans are washed and soaked, passed through a mincer and mixed with water, pressed between two heavy pots, liquid soymilk and press cake separated, soymilk boiled, packaged and consumed (Table 15). This process costs about $.082 for each kg of soybeans, and results in two kg of moist press cake and six liters of soymilk worth a total of $3.77. This slightly diluted soymilk is suitable for making the sweet African tea preferred by many communities and is indistinguishable from that prepared using cow's milk. In West Africa, the same basic procedure is followed except that soaked soybeans are pounded using a large traditional wooden mortar and pestle and "pressed" by wringing the cloth. This procedure is fast, women will typically meet to share the apparatus at a local center and return home after 40 minutes or so carrying soymilk for their families. Alternatively, soymilk may be produced and sold as hot tea alongside other snacks from a kiosk at marketing centers and bus stations.

This soymilk is also lifesaving. For example, ten year-old Jared Andere is one of 15 orphans supervised by a small church in west Kenya. Jared was the most severely malnourished of these children and nearly died until receiving a 10 day treatment including soymilk provided by a N2Africa partner, Josephine Ongoma of Kleen Homes and Gardens. Now, each of these 15 children receive 300 ml of fresh soy milk daily from Josephine's group. Soon thereafter, the children's skin changed from scaly dry to soft and smooth; their hair changed from reddish and brittle to dark, shiny and strong; and their demeanor changed from weak and lethargic to playful, outspoken and energetic. Through the efforts of N2Africa, soymilk literally saved Jared's life and is improving the well-being of several other children. These sorts of benefits have huge potential for up-scaling. For example, trainers in Mozambique were instructed in preparing eight nutritious soy products and extended this information to 1498 women, with demonstrations also conduced at health centers promoting antenatal and postnatal health. ***While not stated implicitly in the Vision of Success, improvement of the lives of the poor and vulnerable through improved nutrition is already an outcome of our project.***

10.4 Value adding enterprise: industrial textured vegetable protein.

At the other extreme of value-added processing is the industrial production of textured vegetable protein using soybean flour, corn starch, salt and spices. This product costs only a fraction as much as beef or chicken (about $0.15 per serving), but used identically in traditional stews ready in only 15 minutes. The cooked pieces are easily confused with chicken in terms of color, texture and taste. This product is best prepared using "culinary varieties" of soybeans containing less than 19% oil so that the protein aggregates are firm and do not develop off flavor. The project is actively promoting these varieties, particularly the promiscuously nodulating SB 19. One such manufacturer, Promasidor, produces SOSSI and was the first large-scale buyer to link with N2Africa farmer groups in Kenya.

In conclusion, the vision of both profitable accompanying BNF technologies and value adding enterprises is sound as it relates to soybean in all regions, and cowpea in West Africa. It requires further examination with other grain legumes, particularly groundnut. In East and southern Africa, opportunities for bean and cowpea are likely to remain more confined to household consumption and marketing of whole dried grain with significant impacts on household and community nutrition.

11. Conclusions, lessons learned and recommendations

11.1 Conclusion

A mid-project assessment of the N2Africa Vision of Success was performed; both in terms of its quantitative targets and broader goals. The project is performing well in terms of reaching farmers, closing yield gaps and increasing BNF. Soybean and cowpea are performing well but increased performance by bean and groundnut fall below initial estimates. As of Year 2, household participation was 16% higher than anticipated, yield increases were 20% below target (-280 kg per ha) and estimated, increased BNF was 93% of expected. The projected increase in household incomes is less than originally offered, in large part because of its assumption that every household would adopt improved grain legume enterprise on one ha. A more realistic target income is + $226 per year, and along current trajectory this goal is 73% achievable. A review of the project's dissemination of BNF technologies indicates the need for flexibility and responsiveness, with different countries pursuing courses of opportunity involving diverse partnership strategies. The envisaged farmer-to-grassroots trainer ratio of 132:1 was increased to 94:1 in order to better reach and work with the assigned numbers of households. Dissemination tools relating to BNF and grain legume technologies were required immediately within extension campaigns, not by Month 6 Year 2 as originally planned, and 39 such tools were developed through Year 2, 23 more than expected. Progress was made initiating community-based seed production and linking farmers to markets, but these efforts remain about 12% below target, in large part because some farmers retained sufficient seed for themselves (as opposed to others) and lacked marketable surpluses after only one or two growing seasons. The number of sponsored extension, media and nutrition events exceed expectation by 1.7- to 2.7-fold, and women's participation remains on target with 50% women involved in all rural activities. Project targets for training agro-dealers in marketing products relating to BNF and legume management by Year 2 were not reached and corrective actions for Year 3 are underway. Four overarching objectives; linking farmers' nitrogen needs to the atmosphere, providing new sources of income, advancing renewable soil fertility management and offering profitable accompanying technologies and value-added enterprises are on track and illustrated by a series of examples. Soybean production in west Kenya offers benefit-to-cost ratios of 3.6. Nitrogen balances are positive for all crops except bean, range between +10 to +28 kg N per ha per season, and farmers have several opportunities to manage the residues containing this nitrogen. Climbing bean is likely to have a positive N balance and deserves greater attention over the next two years. Inoculants sold for $2.50 per 100 g offer sufficient profits to both manufacturers and retailers. Local soymilk production is feasible, profitable and offers greatly improved nutrition to the poor and vulnerable. Industrial production of textured vegetable protein from soybean offer new markets to project farmers and a tasty, affordable source of protein to consumers. Increased production of blended animal feed offers similar opportunity. The N2Africa Vision of Success set a challenging set of goals that are largely being achieved and often exceeded, and the project has demonstrated ability to take necessary corrective actions where it has fallen behind.

11.2 Lessons Learned

1. Difficulties were experienced in closing yield gaps for bean and groundnut, and this shortcoming is often related to production constraints beyond the scope of BNF technology.
2. Estimates of BNF based on crop yield can be generated by simple "transfer functions" involving seed nitrogen, N derived from fixation, and N harvest index derived from the scientific literature, but these estimates must be calibrated and validated through field measurements.
3. The key to meeting household income targets rests in the increase of farm area adopted into legume cultivation and appears most feasible for soybean and cowpea production.
4. Recalculating the project's quantitative targets for yield, BNF and household income should include averages weighted to the number of households offered technologies for different legumes, and not the simple average of those four legumes. Weighted averages that factor the number of households adopting soybean are higher in terms of yield, BNF and income generation and this offers a more accurate and favorable overall refection on the project.
5. Differences in growing season characteristics, both in terms of timing and pattern, must be considered when scheduling farmer participation within the project. Some countries receiving late monomodal rainfall were unable to meet their first year targets because this was not adequately considered in initial project planning. Conversely, other countries with early and mid-year bimodal precipitation exceeded original expectation.
6. Original farmer-to-grassroots trainer ratios were too wide (132:1) and required adjustment (94:1). Fewer trainers are required in Action Sites receiving bimodal rainfall because they are able to reach new farmer groups twice a year. Trainers are expected to understand both theoretical and practical aspects of BNF and to explain them in terms understandable to farmers. This entails translation of training materials into several local languages.
7. Linking participating communities to farmer groups before reliable crop surpluses are available may become counterproductive as buyers seek to purchase stored grain that is otherwise needed for seed

the following season. This seed is essential as "rolling stock" to meet project goals and incentives must be offered to secure these materials.

8. Levels of mechanistic understanding of BNF varies greatly among farmers. Some understand it as a microbially-mediated process but this is too complex for most, and these differences are most likely related to levels of education. Farmers need not completely understand BNF to practice our recommended legume managements but inoculant handling and storage may be compromised. Project trainers are prepared to explain BNF at a range of levels.
9. Households are often unprepared to utilize soybean compared to bean, cowpea and groundnut. Simple preparations are available to better integrate soybean into family diets and are being promoted through cooking exhibits, grassroots training and extension booklets. Local preparation of soymilk is one means of improving household and community nutrition among the rural poor and most vulnerable that are least able to access cow's milk.

11.3 Recommendations

1. Agronomic research must place greater priority in raising the productivity of bean and groundnut so that project targets may be more completely achieved.
2. Measurements of BNF under initial field conditions and improved legume managements remain lacking and this greatly affects our understanding of project impacts. The Legume Agronomy Research team must address this shortcoming immediately and if necessary drop peripheral lines of research in order to do so. Field measurement of BNF should then be correlated with transfer functions and progress in meeting BNF targets recalculated.
3. As households increasingly adopt BNF technologies and grain legume enterprises promoted by the project, it is important that M&E address the new areas falling into cultivation and the economic returns being achieved. This will better allow the project to assess the increased income enjoyed by farmer clients.
4. The project has performed well in meeting most its extension goals but its media events tend to be simplistic and localized. Whenever possible, country teams should better engage with national news media.
5. The project has achieved humanitarian impacts not anticipated in the project proposal and case studies should be launched by the project's M&E team to capture them.

Finally, we offer this revised Vision of Success based upon two years of project experience and household-weighted calculation of impacts

*"To raise average grain legumes yields by **1010 kg/ha** in four legumes (soybean, common bean, cowpea and groundnut), increase average biological nitrogen fixation (BNF) by **58 kg/ha**, and increase average household income by **$226**, directly benefiting **300,000 households (2,400,000 individuals)** in eight countries in sub-Saharan Africa (DRC, Ghana, Kenya, Malawi, Mozambique, Nigeria, Rwanda, Zimbabwe). Indeed, this project links the protein and nitrogen needs of poor African farmers directly to previously inaccessible, massive atmospheric reserves, provides them with new income-generating crop production enterprises, presents a mechanism of renewable soil fertility management, opens the door to the adoption of numerous, profitable accompanying farm technologies and value-adding enterprises **and contributes to humanitarian goals among Africa's poorest and most vulnerable**".*

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Photos of N2Africa dissemination in action. A seed processing kit was distributed to cooperators that included a sieve, scale, moisture meter and germination dishes (left). A woman Master Farmer explains nodulation occurring within a BNF Technology Test (center). Mincing soybeans during the five-step procedure for local production of soymilk (right).

List of project reports

1. N2Africa Steering Committee Terms of Reference
2. Policy on advanced training grants
3. Rhizobia Strain Isolation and Characterisation Protocol
4. Detailed country-by-country access plan for P and other agro-minerals
5. Workshop Report: Training of Master Trainers on Legume and Inoculant Technologies (Kisumu Hotel, Kisumu, Kenya-24-28 May 2010)
6. Plans for interaction with the Tropical Legumes II project (TLII) and for seed increase on a country-by-country basis
7. Implementation Plan for collaboration between N2Africa and the Soil Health and Market Access Programs of the Alliance for a Green Revolution in Africa (AGRA) plan
8. General approaches and country specific dissemination plans
9. Selected soybeans, common beans, cowpeas and groundnuts varieties with proven high BNF potential and sufficient seed availability in target impact zones of N2Africa Project
10. Project launch and workshop report
11. Advancing technical skills in rhizobiology: training report
12. Characterisation of the impact zones and mandate areas in the N2Africa project
13. Production and use of Rhizobial inoculants in Africa
18. Adaptive research in N2Africa impact zones: Principles, guidelines and implemented research campaigns
19. Quality assurance (QA) protocols based on African capacities and international existing standards developed
20. Collection and maintenance of elite rhizobial strains
21. MSc and PhD status report
22. Production of seed for local distribution by farming communities engaged in the project
23. A report documenting the involvement of women in at least 50% of all farmer-related activities
24. Participatory development of indicators for monitoring and evaluating progress with project activities and their impact
25. Suitable multi-purpose forage and tree legumes for intensive smallholder meat and dairy industries in East and Central Africa N2Africa mandate areas
26. A revised manual for rhizobium methods and standard protocols available on the project website
27. Update on Inoculant production by cooperating laboratories
28. Legume Seed Acquired for Dissemination in the Project Impact Zones
29. Advanced technical skills in rhizobiology: East and Central African, West African and South African Hub
30. Memoranda of Understanding are formalized with key partners along the legume value chains in the impact zones
31. Existing rhizobiology laboratories upgraded
32. N2Africa Baseline report
33. N2Africa Annual country reports 2011

34. Facilitating large-scale dissemination of Biological Nitrogen Fixation
35. Dissemination tools produced
36. Linking legume farmers to markets
37. The role of AGRA and other partners in the project defined and co-funding/financing options for scale-up of inoculum (banks, AGRA, industry) identified
38. Progress Towards Achieving the Vision of Success of N2Africa

Partners involved in the N2Africa project

Caritas Rwanda

Diobass

Eglise Presbyterienne Rwanda

Nairobi University

Resource Projects-Kenya

Université Catholique de Bukavu

University of Zimbabwe