UNIVERSITE D'ANTANANARIVO

ECOLE SUPERIEURE DES SCIENCES AGRONOMIQUES

ECOLE DOCTORALE AGRICULTURE, ELEVAGE, ET ENVIRONNEMENT

THÈSE DE DOCTORAT EN SCIENCES AGRONOMIQUES

GESTION DES RESSOURCES NATURELLES COMME MOYEN D'ADAPTATION AU CHANGEMENT CLIMATIQUE DES MENAGES RURAUX DANS LES DEUX ECOREGIONS EST ET OUEST DE MADAGASCAR

Présentée par

Zo Lalaina Randriarimalala

Le 15 Septembre 2015 devant le jury composé de :

RASOARAHONA Jean	Professeur titulaire, ESSA, Université d'Antananarivo	Président
RABEHARISOA Lilia	Professeur titulaire, ESSA, Université d'Antananarivo	Directeur de thèse
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RAZAFIMBELO Tantely	Professeur, ESSA, Université d'Antananarivo	Examinateur
RAZANAKA Samuel	Professeur, Directeur de Recherche au Centre National de Recherche sur l'Environnement	Examinateur

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Résumé

Les forêts tropicales sont cruciales pour les communautés rurales à travers le monde, en fournissant des biens et services clés qui soutiennent leurs moyens de subsistances, et en servant de filet de sécurité lors des risques et catastrophes naturels.

Toutefois, a Madagascar, les communautés rurales font face à deux menaces majeures et imbriquées: le changement climatique (qui menace leur productivité agricole et les moyens de subsistance) et la perte et la dégradation de forêt (qui affectent la disponibilité des produits forestiers et ses services ecosystemiques. Compte tenu de la grande pauvreté des petits agriculteurs Malgaches et leur extrême vulnérabilité au changement climatique, il est urgent de mieux comprendre comment les agriculteurs sont touchés par le changement climatique, comment ils font face à ces impacts et quelles sont les stratégies d'adaptation qui pourraient les aider à améliorer leur résilience, tout en conservant les forêts restantes. Cette information est nécessaire à la fois pour mettre à jour les stratégies existantes en matière d'agriculture, du changement climatique et de développement et aussi pour aider le développement du Plan d'Action National pour l'Adaptation au Changement Climatique qui est en cours.

L'objectif global de la présente étude était de comprendre les impacts du changement climatique et des risques agricoles sur les moyens de subsistance des petits exploitants agricoles (400- 600 menages), d'évaluer la façon dont ils utilisent les ressources naturelles pour faire face à ces risques, et d'identifier des recommandations pour aider les agriculteurs à s'adapter au changement climatique sans dégrader les écosystèmes forestiers restants.dans le corridor Ankeniheny Zahamena, le complexe Mahavavy Kinkony et la zone de Nosivolo.

Cette étude a mis en évidence l'extrême vulnérabilité des petits agriculteurs aux risques agricoles et l'importance des services d'approvisionnement forestiers pour aider les petits agriculteurs à faire face aux impacts du changement climatique. Il souligne également la réduction continue des produits forestiers. Comme recommandations, il sera important que les stratégies nationales existantes pour le développement rural, la lutte contre la pauvreté, la sécurité alimentaire, la protection et de la gestion des ressources naturelles, et le changement climatique reconnaissent le rôle clé des forêts en soutenant les moyens de subsistance ruraux et en servant de filets de sécurité suite à des événements climatiques extrêmes, et prennent des mesures pour assurer leur la conservation et l'utilisation durable.

Mots clés : Ankeniheny Zahamena, cyclone, forets, Mahavavy Kinkony, Nosivolo, petits paysans, services écosystémiques, stratégies d'adaptation, et variabilité climatique.

Summary

Tropical forests are critical for rural communities across the world, providing key products and services that sustain their livelihoods and serving as key safety nets for communities following natural disasters. However, in Madagascar, rural communities are facing two major and intertwined threats: climate change (which threatens their agricultural productivity and livelihoods) and ongoing forest loss and degradation (which affect the availability of forest products and its ecosystem services. Given the high poverty of Malagasy smallholder farmers and their extreme vulnerability to climate change, there is an urgent need to better understand how farmers are being impacted by climate change, how they are coping with these impacts) and what adaptation strategies could help improve the resiliency of smallholder farming communities, while conserving the remaining forests. This information is needed both to update existing agricultural, climate change and development strategies and also to inform the ongoing development of the National Action Plan for Climate Change Adaption.

The overall objective of this study was to understand the impacts of climate change and agricultural risks on the livelihoods of smallholder farmers (400 to 600 households), assess how farmers use forest ecosystems cope with these risks, and identify recommendations on how to help farmers adapt to climate change without degrading the remaining forest ecosystems in the Ankeniheny Zahamena corridor, the Mahavavy Kinkony complex and the Nosivolo area.

The study highlights the extreme vulnerability of smallholder farmers to agricultural risks and climate change and the importance of forest provisioning services in helping smallholder farmers cope with climate change impacts. It also highlights the ongoing decline of forest products. As recommendations, it will be important that existing National strategies for rural development, poverty alleviation, food security, natural resources protection and management, and climate change acknowledge the key role of forests in supporting rural livelihoods and in serving as safety nets following extreme weather events, and take steps to ensure their conservation and sustainable use.

Key words: adaptation strategies, Ankeniheny Zahamena, climate variability, ecosystem services, forest, Mahavavy Kinkony, Nosivolo, smallholder farmers.

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Liste des abréviations

BNGRC	Bureau National pour la Gestion des risques et catastrophes
CAZ	Corridor Ankeniheny Zahamena
CMK	Complexe Mahavavy Kinkony
CSA	Centre de Services Agricole
EbA	Ecosystem-based Adaptation
FAO	Food and Agriculture Organization
FIDA	Fonds International de Développement Agricole
GIEC	Groupe d'experts intergouvernemental sur l'évolution du climat
GNI	Per capita gross national income
GTCC	Groupe Thématique pour le Changement Climatique
IAASTD	International Assessment of Agricultural Knowledge, Science and Technology for Development.
INSTAT	Institut National de la Statistique de Madagascar
IPCC	Intergovernmental Panel on Climate Change /
MEA	Millenium Ecosystem Assessment
MEEF	Ministère de l'Environnement, des Eaux et Forets
MEF	Ministère de l'Environnement et Forets
MEFT	Ministère de l'Environnement, des Forets et du Tourisme

NSV	Nosivolo area
NTPF	Non-timber forest products
ONE	Office National pour l'Environnement
PADR	Plan d'Action pour le Développement Rural
PANA	Programme d'Action Nationale d'Adaptation au changement climatique
PANLCD	Plan d'Action National de Lutte contre la Désertification
PANSA	Plan d'Action National pour la Sécurité Alimentaire
PNAE	Plan National d'Action pour l'Environnement
PNLCC	Politique Nationale de Lutte contre le Changement Climatique
REDD	Réduction des émissions déforestation et dégradation forestières
PPP	Purchasing power parity: Parité de pouvoir d'achat
TFNAC	Task Force National pour l'agriculture de Conservation
UNDP	United Nations Developpement Programme
UNEP	United Nations Environment Programme
UNHRC	United Nations Human Rights Council
UNICEF	United Nations Children's Fund
WFP	World Food Programme
YAMC	Young Men Christian Association of Madagascar

Glossaire

Adaptation : Accommodation des systèmes naturels ou des systèmes humains aux stimuli climatiques réels ou prévus ou à leurs effets, afin d'en atténuer les inconvénients ou d'en tirer des avantages (GIEC)

Atténuation : Intervention humaine visant à réduire le forçage anthropique du système climatique ; elle comprend des stratégies visant à réduire les sources et les émissions de gaz à effet de serre, et à renforcer les puits de gaz à effet de serre (GIEC).

Capacité d'adaptation : Capacité d'un système de s'adapter aux changements climatiques (notamment à la variabilité climatique et aux phénomènes extrêmes), afin d'atténuer les dommages potentiels, e tirer parti des possibilités offertes, ou de faire face aux conséquences.

Changements climatiques : Les changements climatiques désignent des changements du climat qui sont attribuées directement ou indirectement à une activité humaine altérant la composition de l'atmosphère mondiale, et qui viennent s'ajouter à la variabilité naturelle du climat observée au cours de périodes comparables (CCNUCC). La CCNUCC fait ainsi la distinction entre les « changements climatiques » qui peuvent être attribuées aux activités humaines altérant la composition de l'atmosphère, et la « variabilité climatique » due à des causes naturelles

Gestion adaptive : un processus systématique d'amélioration constante des politiques et pratiques de gestion qui se base sur les leçons tirées des résultats de politiques et pratiques antérieures.

Parité des pouvoirs d'achat (PPA) : Estimations du *Produit intérieur brut* basées sur le pouvoir d'achat des devises plutôt que sur les taux de change.

Résilience : Capacité d'un système social ou écologique d'absorber les perturbations tout en conservant sa structure de base et ses modes de fonctionnement ; capacité de s'organiser et de s'adapter au stress et aux changements (GIEC)

Sécheresse : Phénomène résultant d'une insuffisance marquée des précipitations, qui donne lieu à un déséquilibre hydrique souvent préjudiciable aux ressources en sols et aux systèmes de production (GIEC)

Sécurité alimentaire : Situation dans laquelle les personnes ont un accès assuré à une nourriture saine et nutritive en quantités suffisantes pour leur garantir une croissance normale et une vie saine et active. L'insécurité alimentaire peut résulter d'un manque de nourriture, d'un pouvoir d'achat insuffisant, de problèmes de distribution ou d'une mauvaise utilisation des aliments dans les ménages (GIEC)

Services écosystèmiques : Processus ou fonctions écologiques ayant une *valeur* pour les individus ou la société.

Variabilité du climat : Variations de l'état moyen et d'autres statistiques (écarts-types, phénomènes extrêmes) du climat à toutes les échelles temporelles et spatiales au-delà de la variabilité propre à des phénomènes climatiques isolés. La variabilité peut être due à des processus internes naturels au sein du système climatique (variabilité interne) ou à des variations des forçages externes naturels ou anthropiques (variabilité externe) (GIEC)

Vulnérabilité : Mesure dans laquelle un système est sensible – ou incapable de faire face – aux effets défavorables des changements climatiques, y compris les variabilités du climat et les phénomènes extrêmes. La vulnérabilité est fonction de la nature, de l'ampleur et du rythme de la variation du climat à laquelle le système est considéré exposé, de la sensibilité de système et de sa capacité d'adaptation

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INTRODUCTION GENERALE

La majorité de la population Malgache sont des agriculteurs et l'économie de Madagascar dépend largement de l'agriculture. Malheureusement les moyens de subsistance des petits exploitants agricoles sont handicapés par la pauvreté, et menacés par le changement climatique, et l'épuisement des services des écosystèmes. L'objectif global de la présente thèse est de comprendre les impacts du changement climatique et des risques agricoles sur les moyens de subsistance des petits exploitants agricoles, et d'évaluer la façon dont ils utilisent les ressources naturelles pour faire face à ces risques.

Cette étude est composée de trois parties rédigées en anglais, avec une introduction générale et une conclusion générale rédigées en français.

La première partie décrit la vulnérabilité des petits exploitants agricoles face aux risques agricoles et ceux liés au changement climatique à Madagascar, plus spécifiquement dans la région Alaotra Mangoro, le Complexe Mahavavy Kinkony et la zone de Nosivolo. Elle est basée sur une enquête auprès de 600 ménages. Elle décrit également la perception du changement climatique par les petits paysans sur les dix dernières années, l'impact du changement climatique et les différentes stratégies de gestion des risques. Parmi celles-ci, il y a la diversification des cultures, l'ajustement de calendrier cultural et les stratégies non-liées à l'agriculture telle que l'utilisation des produits forestiers.

Cette dernière option fait l'objet de la deuxième partie de l'étude. En effet, celle-ci décrit l'utilisation des ressources naturelles dans le corridor Ankeniheny Zahamena comme moyen d'adaptation au changement climatique des petits exploitants agricoles. L'étude a porté sur un échantillon de 200 ménages et inclut une analyse du changement du couvert forestier pendant la même période. Il est constaté que les ressources forestières sont plus intensément utilisées dans le contexte d'adaptation au changement climatique. Ce constat sera davantage confirmé dans l'étude de cas, objet de la troisième partie, portant sur le Corridor Ankeniheny Zahamena et la zone Nosivolo.

Effectivement, parmi les risques liés au changement climatique, il y a la sécheresse et le cyclone. Juste après notre enquête en Décembre 2011, le cyclone Giovanna était passé à Madagascar et avait laissé beaucoup de dégâts surtout dans la région Alaotra Mangoro. Ainsi,

nous avons voulu confirmer les résultats de nos précédentes études en faisant procédant à une enquête auprès de 100 ménages, focalisé sur les stratégies d'adaptation post-cycloniques. Avant la présentation des résultats des travaux de recherches, l'étude passe par une présentation de l'état des connaissances sur l'importance des petits exploitants agricoles dans le monde et à Madagascar, suivie d'une description des services des écosystèmes forestiers et du changement climatique à Madagascar, pour enchaîner ensuite sur la problématique. Celle-ci est décrite dans la dernière partie de l'introduction, focalisée les relations entre les modes de vie des ménages ruraux, le changement climatique et les forêts.

1. Etat de connaissance sur l'importance des petits exploitants agricoles, les écosystèmes forestiers, et le changement climatique à Madagascar

1.1. Importance des petits exploitants agricoles

Les petits agriculteurs sont globalement définis comme ceux exploitant moins de 2 ha de terres cultivables (World Bank, 2003; FIDA, 2013) et la plupart d'entre eux sont dans des pays en développement en Afrique (Sanchez and Swaminathan, 2005). La Fédération internationale des producteurs agricoles estime qu'il y a au moins 450-500 millions de petits agriculteurs dans le monde entier, et ils représentent 85% des exploitations agricoles du monde (Nagayet, 2005). Bien que les petits agriculteurs aient tendance à être pauvres, ils contribuent à la réduction de la pauvreté et à la sécurité alimentaire et fournissent "80% de la nourriture consommée dans la majorité des mondes en développement" (FIDA, 2013). Il est estimé que 70 pour cent de l'approvisionnement alimentaire en Afrique sont fournis par les petits exploitants agricoles (IAASTD, 2009). L'analyse de la pauvreté au niveau mondial a montré que celle-ci est essentiellement rurale : 70% des personnes très pauvres résident en milieu rural, (FIDA, 2013), et 1 milliard de personnes souffrent de la faim (FIDA, 2013).

A Madagascar, il est estimé que 80% des 21 millions d'habitants sont constitués par la population rurale et 90% d'entre eux utilisent l'agriculture comme principale source de moyens d'existence (Kistler and Spack 2003 ; Stifel and Minten 2007 ; INSTAT, 2011). Parmi ces ménages agricoles, environ 70% d'entre eux sont de petits agriculteurs avec moins de 1,5 ha de terres cultivées (WFP and UNICEF, 2011; INSTAT, 2011). Comme dans d'autres pays en voie de développement, ces petits agriculteurs Malagasy sont relativement pauvres, car 82% de la population rurale sont en dessous du seuil de pauvreté national (INSTAT, 2011), et la moyenne annuelle de revenus des ménages agricoles au niveau

national est de 910.000Ar. En plus, l'infrastructure nécessaire pour l'agriculture en milieu rural tels que les systèmes d'irrigation et les routes sont mal entretenus (WFP and UNICEF, 2011; INSTAT, 2011). Toutefois, les activités agricoles contribuent significativement à l'économie malgache, à hauteur de 26% du PIB (WFP and UNICEF, 2011) et à la sécurité alimentaire. Environ 95% des apports alimentaires Malgache et 75% des recettes des devises proviennent du secteur agricole (MEF; 2007).

Même si les régions d'Alaotra Mangoro et de Boeny (où se sont déroulées les enquêtes) sont parmi celles qui ont un revenu relativement élevé par rapport aux autres régions de l'île, la proportion de petits exploitants pauvres dans le corridor Ankeniheny Zahamena, dans le complexe Mahavavy Kinkony et dans la zone de Nosivolo est similaire à celle observée au niveau national (Ministère de l'agriculture, 2004). Ces agriculteurs pratiquent des cultures vivrières telles que le riz, le maïs, la patate douce et le manioc et les cultures de rente telles que le litchi, de caféiers, et les clous de girofle (Ministère de l'Agriculture, 2009) ; pour les deux régions, la riziculture constitue la principale source de revenus (INSTAT, 2011), et l'Alaotra Mangoro est l'une des régions les plus productrice du riz à Madagascar avec un taux de 11,4% de la production totale du riz (Ministère de l'Agriculture 2009; INSTAT, 2011).

Il est admis que le meilleur rendement agricole et l'efficacité de la contribution de l'agriculture sur l'économie Malgache et sur la sécurité alimentaire dépendent des services fournis par le bon fonctionnement des écosystèmes forestiers, y compris la fertilité du sol, la source en eau, la pollinisation et la lutte antiparasitaire (FIDA, 2013).

1.2. Services des écosystémiques forestiers

Les forêts fournissent de services écosystèmiques très variés, et d'une valeur économique énorme (Costanza et al., 1997; Chomitz, 2006). En s'alignant sur la classification adoptée pour l'évaluation des écosystèmes du millénaire, lesdits services sont de quatre catégories : les services de production, les services de régulation, les services culturels et le soutien de la diversité biologique (MEA, 2005; Fischlin et *al.,* 2007; Seppälä et *al.,* 2009 ; MEF, 2009).

Service de production ou d'approvisionnement

Les forêts fournissent deux types de produits : les produits ligneux et les produits non ligneux. Parmi les produits ligneux, il y a les bois de construction, les bois de chauffe et les fibres. Parmi les produits non ligneux, on peut citer les produits pharmaceutiques, les

aliments et produits comestibles (fruits sauvages, tubercules, gibiers), les produits pour la fabrication d'ustensiles et d'objets d'artisanat et pour la construction, les plantes ornementales, les produits animaux et la matière première, les produits pour la fabrication des colorants ou teintures et les exsudats (résines, latex, parfum, aromes) (FAO, 2003; Richardson, 2010; FAO, 2014 ; MEF, 2014; Seymour 2014 ;).

Toujours parmi les services de production, on peut citer également l'approvisionnement en eau potable, en eau d'irrigation, et en air respirable (MEA, 2005; Pipa and Calen, 2011). Beaucoup de villes ont des réservoirs d'eau potable alimentés par des fleuves, des rivières ou des canalisations qui ont leur source dans les forêts. Il en est de même pour les périmètres rizicoles irrigués. Le même service de production approvisionne les centrales hydro-électriques.

Services de régulation

Le service de régulation assuré par les forêts s'apprécie à deux niveaux : au niveau local et au niveau global. Au niveau local, les forêts assurent la régulation des crues et la rétention des sols contre l'érosion ; toujours au niveau local, les forêts assurent le phénomène de formations des pluies, et l'approvisionnement de la nappe phréatique (FAO, 2014).

Au niveau global, les forêts assurent des fonctions de régulation hydrologiques, dont l'augmentation de la précipitation et l'évapotranspiration. D'autre part, toujours au niveau global, les forêts assurent la séquestration du carbone atmosphérique (MEA, 2005; Pipa et Calen, 2011; FAO, 2014).

Services sociaux et culturels

Beaucoup de sites de recréation se trouvent dans les forêts. D'autre part, beaucoup de populations autochtones associent les forêts à des valeurs culturelles autres que touristiques : des croyances et des tabous (MEA, 2005). A Madagascar, il y a des forêts sacrées qui jouent un rôle important pour la pratique des us et des coutumes (MEF, 2014).

Services de soutien

Les forêts sont généralement reconnues comme des réservoirs de biodiversité terrestre (MEA, 2005; FAO, 2014). L'importance de la biodiversité forestière s'apprécie de deux manières: d'abord de par son existence-même, comme partie importante de la biodiversité globale; ensuite, par sa valeur utilitaire, étant une source de nombreuses ressources biologiques

utilisées par les populations (Pipa and Calen, 2011). Cette fonction de soutien de la diversité biologique supporte les autres services écosystémiques (MEA, 2005).

La forêt tropicale de Madagascar est caractérisée par sa richesse en matière de diversité biologique. Il est reconnu mondialement comme un pays à Megadiversité (Mittermeier et *al.,* 1997) mais également caractérisé comme un pays 'Hotspot' ou un point chaud pour la biodiversité. Les pays Hotspot sont caractérisés par la présence d'au moins 1500 espèces végétales endémiques mais qui ont déjà perdu au moins 70 % des espèces présentes dans leur état originel (Mittermeier et *al.,* 1998). Mais Madagascar sert comme habitat d'environ 12000 à 13000 espèces floristiques dont 80% sont endémiques (MEF, 2014). Les sites d'étude retenus pour cette étude sont caractérisés par une présence importante de forêts denses : des forêts denses sèches pour Mahavavy Kinkony, et des forêts denses humides pour Ankniheny-Zahamena et Nosivolo.

D'une part, cette richesse joue un rôle crucial sur la qualité et la quantité des services des écosystèmes forestiers ; elle est également la base de la résilience intrinsèque des écosystèmes. D'autre part, la résilience des écosystèmes au changement climatique est la base de la résilience des communautés rurales y compris les petits exploitants agricoles (Hammill et *al.,* 2005 ; MEA, 2005). Pour améliorer la résilience de ceux-ci, l'Etat Malgache a mis au point des programmes touchant directement le développement des modes de vie des ménages et des programmes adressant la résilience des écosystèmes.

1.3. Aperçu général de quelques documents cadres nationaux relatifs à l'agriculture, à l'environnement, et au changement climatique

Trois documents traduisent la politique nationale du pays en matière d'adaptation au changement climatique: le Programme d'Actions National d'Adaptation (PANA) (MEF, 2007), la Politique Nationale de Lutte contre le Changement Climatique (PNLCC), et le Plan National de Lutte contre la Désertification (PANLCD) (MEF, 2011). D'autres plans sectoriels plus ou moins liés au changement climatique et la lutte contre la pauvreté existent également: le Plan National d'Action Environnemental (PNAE) (GOM, 1990), le Plan National pour la Sécurité Alimentaire (PANSA) et le Plan d'Action pour le Développement Rural (PADR) (GOM, 2005).

La Convention sur le Climat fait partie des Conventions issues de Rio dont Madagascar est signataire. Les pays signataires «en développement» et avaient l'obligation de soumettre un Programme d'Actions pour l'Adaptation (PANA) au changement climatique, avaient reçu un

financement spécifique pour son élaboration. Les grandes orientations du PANA sont : a) le renforcement de capacité, et b) la réforme des politiques et l'intégration de l'adaptation au changement climatique dans les politiques sectorielles et les activités des projets (MEF, 2007). Le PANA a été établi à une période où les connaissances sur le changement climatique et la vulnérabilité sont insuffisante, une mise à jour régulière a été envisagée par le Ministère de l'Ecologie, l'Environnement, de la Mer et des Forets (http://www.ecologie.gov.mg).

La politique nationale de lutte contre le changement climatique (PNLCC) a été élaborée en 2010 pour suppléer l'absence de cadre (autre que la Convention) pour la mise en œuvre du protocole de Kyoto, et faire le lien entre ce protocole et l'adaptation au changement climatique au niveau du pays. En plus, elle a été établie alors que la REDD est en plein développement à Madagascar, fournissant une opportunité de lutter contre le changement climatique en dehors du cadre officiel de la Convention (si le sommet de Bali en 2007 a juste reconnu les projets de démonstration, des avancées ont été enregistrés aux sommets de Poznan (2008) et de Copenhague (2009), de sorte que le REDD est actuellement reconnu comme une composante majeure de la lutte contre le réchauffement climatique de même que ses autres variantes (REDD+). Ces stratégies REDD+ « mettent l'accent sur le rôle de la conservation, de la gestion durable des forêts et du renforcement des stocks de carbone forestier dans la réduction des émissions » (www.redd.org). Les grandes orientations de cette Politique sont :a) renforcement des actions d'adaptation au changement climatique tenant en compte des besoins réels du pays. b) mise en œuvre des actions d'atténuation au profit du développement du pays, c) intégration du changement climatique à tous les niveaux, d) développement des instruments de financements pérennes, et e) promotion de la recherche, développement et transfert de technologie et la gestion adaptive (MEF, 2010b).

Le PANLCD a été adopté par le décret 199-03 du 11 mars 2003. Il met un accent particulier sur le lien entre la lutte contre la désertification et la gestion des risques et catastrophes (MEF, 2003). Madagascar a la particularité de disposer d'écosystèmes divers, et le Sud malgache connaît un climat subaride. Les diagnostics effectués font état de l'avancée des dunes, qui est un indicateur de désertification. Les évolutions récentes de la Convention intègrent les aspects de dégradation des terres, phénomène qui touche presque l'île entière, étant donné le niveau d'érosion que connaissent les Hauts plateaux malgaches. Les grandes orientations du PNLCD sont :a) amélioration des connaissances sur le processus de désertification, de la prévention et de la gestion des catastrophes et du capital productif et du

cadre de vie des populations, notamment en milieu rural, b) la gestion durable des ressources naturelles, c) la sécurisation foncière et d) l'approche genre.

Madagascar est un des premiers pays qui ont mis en œuvre le PNAE, comme instrument de mise en œuvre de la Charte de l'Environnement, adoptée comme loi en décembre 1990 (GOM, 1990). Ce plan est très ouvert, car il couvre à la fois les aspects de conservation de biodiversité, de conservation des sols et des ressources en eau, et d'amélioration d'un cadre de vie. L'hypothèse principale qui sous-tend la PNAE est que les pressions sur les écosystèmes sont dues à la pauvreté. La PNAE a retenu quatre grandes orientations: a) développer les ressources humaines, b) promouvoir un développement durable, équitable et bien réparti sur le territoire national en gérant mieux les ressources naturelles, c) réhabiliter, conserver et gérer le patrimoine malgache de biodiversité qui est unique au monde et appuyer le développement d'un tourisme original écologique et d) améliorer le cadre de vie des populations rurales et urbaines.

Le Plan d'action pour le Développement Rural (PADR) a été formulé en 1999 par le décret 99-02 (GOM, 2005). Elle est à la fois un cadre de référence pour les interventions en matière de développement rural à Madagascar, et un processus d'identification des champs d'intervention. « Le processus PADR vise l'amélioration de la prise de décision en matière de politique de sécurité alimentaire et de développement rural, par le renforcement de la capacité d'analyse, de suivi et de facilitation de la mise en œuvre, aux niveaux national et régional » (www.epp-padr.mg). Elle a servi, par la suite, à définir la composante de développement rural du pays dans le Document Stratégique de Réduction de la Pauvreté (DSRP). Les grandes orientations du PADR sont: a) assurer une bonne gestion du monde rural par la définition et la mise en œuvre des réformes institutionnelles et du cadre réglementaire, b) inciter l'émergence des acteurs économiques, partenaires du développement rural, c) accroître et promouvoir la production agricole avec une utilisation optimale ainsi qu'une gestion durable des ressources et ces infrastructures, d) assurer une disponibilité alimentaire suffisante dans toutes les régions et e) développer les infrastructures sociales en vue d'améliorer l'accès aux services sociaux.

Le PANSA part d'un état des lieux de la sécurité alimentaire et nutritionnelle à Madagascar, phénomène inséparable de la pauvreté et de la vulnérabilité. Les principaux déterminants de l'insécurité alimentaire mentionnés par le PANSA sont les problèmes économiques et les aspects sociaux et humains (GOM, 2005). A Madagascar, la malnutrition n'épargne aucune

province, et touche aussi bien le milieu rural que le milieu urbain. L'alimentation quotidienne des 53% des ménages ruraux est insuffisante et limitée et 60% de leurs dépenses sont destinées à la nourriture (WFP and UNICEF, 2011). Les grandes orientations du PANSA sont: a) développer une politique de régionalisation de la production agricole, b) renforcer les services d'appui aux producteurs agricoles et les capacités humaines à tous les niveaux, c) promouvoir une politique de stabilisation des marchés et une politique d'information et de suivi d'impact et d) garantir l'accès alimentaire aux plus vulnérables

Ces programmes et plans d'actions nationaux sont fortement imbriqués. Les grandes orientations et les axes stratégiques qui les composent montrent qu'il y a des corrélations fortes entre les modes de vie en milieu rural, la sécurité alimentaire, la lutte contre le changement climatique, la gestion des risques et catastrophes, et la protection de l'environnement. Toutefois, Madagascar est encore parmi les pays pauvre du monde, classé155 ème sur 187 pays (UNDP, 2014, World Bank, 2015). En plus, les impacts des évènements climatiques extrêmes sur les modes d'existence des populations rurales restent alarmants. Prenons comme exemple, au cours du dernier cyclone, Chedza, en 2015, environ 150.000 personnes ont été affectées dont 54.800 déplacées et environ 8.494ha de champ de riz endommagés (BNGRC, 2015). Le coût des dégâts a été estimé à 40 millions de dollars Américains (Jorgic, 2015). Les informations pertinentes sur les mécanismes adoptés par les populations rurales pour faire face aux risques, et le rôle des services écosystémiques fournis par les forêts pour accroître leur résilience sont nécessaires pour la mise à jour des stratégies existantes, et pour le développement du plan d'action national d'adaptation au changement climatique (en cours actuellement).

1.4. Phénomènes climatiques majeurs touchant Madagascar

Madagascar est un des pays très exposés aux risques climatiques extrêmes, notamment les sécheresses, les inondations et les cyclones (Ratsimamanga et Bettencourt, 2007; World Bank, 2013). Les sécheresses sont cycliques à Madagascar et sont conséquentes à un important déficit pluviométrique (Montembault, 2005). Elles touchent principalement les trois régions qui connaissent des climats arides ou subarides du Sud et du Sud-Ouest de l'île avec une saison de pluie qui dure moins de un mois, et une précipitation annuelle inférieure à 500mm (Tadross et *al.,* 2008, WFP and UNCEF, 2011).

Les cyclones sont également cycliques à Madagascar. En moyenne, chaque année, douze cyclones se forment dans le bassin de l'Océan Indien, parmi lesquelles environ quatre touchent la grande île (Tadross *al.,* 2008). Durant les trente dernières années (1975-2005), le nombre de cyclones qui touchent Madagascar est resté stable. Par contre, les cyclones intenses sont devenus plus fréquents (Tadross et *al.,* 2008): si pour la période 1975-1989, un cyclone sur dix a été intense, cette proportion a augmenté jusqu'à un cyclone intense sur quatre pour la période 1990-2004. En effet, 18 cyclones intenses ont été enregistrés pour la première période, alors que 50 ont été enregistrés pour la deuxième période (Tadross et *al.,* 2008).

Dans la région Alaotra Mangoro, notre zone d'étude, BNCRC avait recensé 14.484 sinistres lors de dernier passage du cyclone Chedza en 2015 (BNGRC, 2015).

1.5. Prévisions de changement du climat pour Madagascar

S'alignant sur les modèles régionaux de prévision de changement de la température, de la pluviométrie, des cyclones et du niveau de la mer, les prévisions de changement du climat sont établies sur la base des travaux de l'Université de Cape Town (Tadross et *al.,* 2008).

Une hausse généralisée de la température d'une amplitude variant de 1.1°C à 2.6°C sera observée à l'horizon 2046-2065 (MEFT, 2008). Cette augmentation sera différenciée pour les régions de l'île : elle sera entre 1.1°C et 1.5°C pour l'Extrême Nord, entre 1.2°C et 2.1°C pour la Côte est, entre 1.3°C et 2.3°C sur la Côte Ouest, entre 1.4°C et 2.4°C pour les Hautes Terres, et entre 1.6°C et 2.6°C au Sud (Tadross et al, 2008). Ainsi, le Sud de Madagascar sera le plus affecté par l'augmentation de température, et l'extrême nord sera la moins affectée. Ainsi, la zone actuellement atteinte par les sécheresses connaîtra dans le futur une augmentation de température plus conséquente.

Une diminution de la précipitation annuelle est prévue vers l'horizon 2099. Cette diminution de la précipitation annuelle sera conséquente à une augmentation de la précipitation pendant la saison de pluie, et une diminution plus forte de la précipitation pendant la saison sèche (Raholijao, 2007). Si l'amplitude de la diminution de la précipitation annuelle pourra atteindre 5%, l'augmentation de la pluviométrie en saison de pluie sera de l'ordre de 10%, alors que la diminution de la précipitation en saison sèche pourrait atteindre 30% (Tadross et *al.,* 2008).

La relative augmentation de précipitation en saison de pluie se traduira par une intensification de la pluviométrie. Là encore, le maximum d'augmentation de précipitation en saison de pluie sera observé dans le sud de Madagascar, de même que le maximum de diminution en saison sèche. Par conséquent, les zones connaissant actuellement un climat semi-aride deviendront arides ou subarides (Raholijao, 2007, Tadross et *al.,* 2008).

Pour les cyclones, les tendances actuelles se maintiendront en ce qui concerne le nombre de cyclones touchant l'île (3 à 5 cyclones par an). Par contre, le nombre de cyclones intense augmentera, et de plus en plus de cyclones toucheront le Nord de l'île (Tadross et *al.,* 2008).

Enfin, une augmentation de la température de la mer entre 0.5°C et 0.6°C est prévue pour Madagascar. L'élévation de la mer attendue en 2099 sera entre 20 cm et 50 cm, et cette élévation sera plus forte sur la Côte Ouest que sur la Côte Est (Tadross et *al.,* 2008).

1.6. Les sites d'étude

Pour analyser la contribution de gestion des ressources naturelles sur les moyens d'adaptation au changement climatique des ménages ruraux, trois sites d'étude localisés dans deux écorégions de Madagascar ont été choisis: Le corridor Ankeniheny Zahamena et la zone de Nosivolo qui sont localisés dans l'écorégion Est et le Complexe Mahavavy Kinkony qui est localisé dans l'écorégion Ouest de Madagascar. Les caractéristiques de ces trois sites sont décrites dans la partie méthodologie des articles 1 et 2. Ces sites dans deux écorégions différentes (humide et sèche) ont été choisi pour mieux comparer la vulnérabilité des ménages face au changement climatique et leurs moyens d'adaptations et pour mieux apprécier les rôles des ressources naturelles sur les stratégies d'adaptation des ménages.

2. Problématiques et objectifs

2.1. Modes de vie des ménages ruraux et forêts

En principe, les modes de vie des ménages ruraux sont fortement dépendants de plusieurs facteurs. Parmi ceux-ci, on peut citer l'abondance des services des écosystèmes fournis par les forêts, et la fertilité des sols assurant une production suffisante pour l'autosubsistance (Keck et *al.,* 1994, Abel-Ratovo et *al.,* 2000, Durbin et *al.,* 2003). La mise en valeur des terres n'est possible que si les forêts fournissent les services de régulation de base (stabilisation de l'érosion, régulation des pluies). En lisière de forêts, cette dépendance est plus accentuée (Gorenflo et *al.,* 2011).

La stabilité des frontières entre les zones forestières et les zones agricoles est très précaire. En effet, l'insuffisance des produits agricoles pousse les agriculteurs à étendre les zones agricoles sur les périmètres forestiers (Keck et *al.,* 1994; Chomitz, 2006). D'une part, une réduction des services de régulation offerte par les forêts réduit les potentialités de mise en valeur des terres en aval. D'autre part, les sols forestiers fraichement convertis en zone agricole sont généralement fertiles et préférés par les agriculteurs, étant donné que la fertilité des sols dans les zones agricoles se dégrade progressivement (Styger et *al.,* 2009). Ceci entraine une augmentation de la déforestation. Il est estimé que le taux de dégradation annuel est de l'ordre de 0,4% en 2010 (ONE et *al.,* 2013). Ainsi, une spirale de dégradation de l'environnement est amorcée par le changement d'affectation des terres (la conversion des forêts en terrain de culture) et entretenue par la réduction des services écosystémiques provenant des forêts.

Le changement climatique accentue cette précarité d'équilibre. Le réchauffement planétaire accentue la variation climatique et entraîne de fortes perturbations sur la température et la précipitation (IPCC, 2007). Par conséquent, les services ecosystémiques fournis par les forêts sont de plus en plus sollicités (le service de régulation qui en principe assure un rôle tampon) par les ménages. Ce qui ne peut être assuré que si leur résilience est suffisante. Cette résilience s'est effritée dans le temps, avec la réduction de la superficie forestière et l'appauvrissement de la diversité biologique (Fischlin et *al.,* 2007). Ce déficit est transféré en dehors des zones forestières, au niveau des zones de culture des ménages qui se retrouvent alors démunis face au changement et en subissent les impacts.

2.2. Changement climatique et ménages agriculteurs

La nature même des activités économiques des petits agriculteurs les exposent à la vulnérabilité aux catastrophes naturelles et au changement climatique. D'abord, la pauvreté étant essentiellement rurale dans les pays en développement (FIDA, 2013), elle est caractérisée par l'insuffisance de moyens et l'insuffisance de capacité (UNDP, 2014). Ces insuffisances deviennent très apparentes lors des phénomènes climatiques extrêmes.

Sous les tropiques, les coûts des dégâts cycloniques sont énormes, aussi bien dans le bassin atlantique que dans le pacifique ou l'Océan Indien. Ils se traduisent par des pertes de vies

humaines, des pertes des infrastructures, des pertes de récolte, mais également par des pertes de la capacité des ménages. Beaucoup de pays se trouvant dans la zone intertropicale sont encore sous-développés, ou ayant une part importance de leur population vivant en dessous du seuil de pauvreté. Par conséquent, les ménages et petits exploitants agricoles vivant dans ces pays subissent les impacts des phénomènes climatiques extrêmes, sans toujours disposer de la capacité de réponse nécessaire.

L'analyse des impacts du changement climatique au niveau mondial a mis en évidence la grande vulnérabilité des ménages agriculteurs pauvres face au phénomène (Thomas, 2009 ; FIDA, 2013). En outre, Madagascar fait partie des pays très exposés au changement climatique (Saleemul et Jessica, 2007; Tadross et *al.,* 2008) et aussi bien la chronologie du changement que les prédictions confirment les risques encourus par les ménages. Une variation intense de climat est prévue pour les cent prochaines années et les constats actuels confirment cette tendance (MEFT, 2008 ; Tadross et *al.,* 2008). Avec ces deux paramètres (réduction des services écosystémiques et augmentation des risques liés au changement climatique (sécheresse, inondations, cyclones, invasions de sauterelles)), la productivité agricole diminue et les moyens d'existence des ménages ruraux se trouvent menacés (Montembault, 2005). Pourtant, 80% de la population malgache vit en milieu rural, et 90% des ménages ruraux vivent de l'agriculture (Kistler and Spack 2003 ; Stifel and Minten 2007 ; INSTAT, 2011). Madagascar figure parmi les pays pauvres du monde: 80% de la population ont un revenu au-dessous de 2 USD par jour ; l'incidence de pauvreté est 82.2% dans des secteurs ruraux (INSTAT, 2011; WFP and UNCEF 2011). Ceci est dû aux facteurs multiples, y compris les catastrophes naturelles, la pauvreté, la croissance démographique élevée, la productivité faible, et les politiques économiques inadéquates (WFP and UNICEF, 2011 ; UNDP, 2014). Etant donné que Madagascar est un pays à mégadiversité (Mittermeyer et *al.,* 1997), la solution d'utiliser les zones forestières pour absorber les insuffisances de l'agriculture (due à la fois par l'érosion de la fertilité des sols et le changement climatique) menace le potentiel en biodiversité au niveau du pays et même au niveau mondial. En effet, à cause de la concentration exceptionnellement élevée de la biodiversité sur une aire de distribution restreinte, le défrichement d'un hectare de forêt primaire est plus néfaste à la biodiversité globale à Madagascar que nulle part ailleurs (GOM, 1990).

Ainsi, le pays se trouve entraîné dans une spirale de dégradation de l'environnement avec un taux annuel moyen de déforestation de 0,4% pour Madagascar et de pauvreté avec 81 % de la population rurale, amplifiée par le changement climatique et les risques climatiques extrêmes

comme les sécheresses et les cyclones. Actuellement, Madagascar est en train de réviser le Programme Nationales pour le Changement Climatique et de développer le Plan d'Action National d'Adaptation au Changement Climatique. Des informations pertinentes sur les mécanismes adoptés par les populations rurales pour faire face aux risques, et le rôle des services écosystémiques fournis par les forêts pour accroître leur résilience s'avèrent nécessaires pour alimenter ces stratégies et assurer la cohérence des stratégies existantes telles que le PANA, PNLCC, PADR, PANSA, et PNAE dans le cadre de leur mise en œuvre.

Cette étude a pour but d'analyser les impacts du changement climatique sur les modes d'existence des petits agriculteurs et à évaluer leur adaptation au changement climatique en prenant en considération l'utilisation des ressources naturelles dans le Corridor Ankeniheny Zahamena, le complexe Mahavavy Kinkony et la zone de Nosivolo. Nous avons choisi ces sites d'étude à cause de leur exposition potentielle aux évènements climatiques majeurs: le Corridor Ankeniheny Zahamena et la zone de Nosivolo sont localisés dans la partie humide de l'Est de Madagascar et sont exposés aux cyclones ; le complexe Mahavavy Kinkony est localisé sur la côte Ouest et sèche de Madagascar et est exposé à la sécheresse.

2.3. Hypothèses de Recherche

Les hypothèses à confirmer pour cette recherche sont les suivants :

H1 : La variation climatique a des impacts sur les moyens de subsistance des ménages ruraux dans les zones très enclavées, surtout sur l'économie des ménages et la sécurité alimentaire,

H2 : Les communautés rurales utilisent les écosystèmes forestiers comme filets de sécurité pour faire face aux impacts du changement climatique,

H3 : Les stratégies traditionnelles adoptées par les agriculteurs vulnérables pour faire face aux cyclones ne sont pas efficaces pour atténuer ces impacts.

2.4. Objectifs de ce travail

Objectifs globaux

- Analyser l'impact de changement climatique sur les moyens de subsistances des petits exploitants agricoles et analyser le rôle des écosystèmes naturels pour supporter les petits agriculteurs à s'adapter au changement climatique, et
- Proposer des solutions pour une meilleure compatibilité de l'adaptation au changement climatique à la gestion durable des ressources naturelles.

Objectifs spécifiques

- Evaluer la vulnérabilité des petits exploitants agricoles face aux risques liés à l'agriculture et leurs stratégies traditionnelles pour gérer ces risques
- Analyser le lien entre la résilience des petits exploitants agricoles vis-à-vis du changement climatique et leur utilisation des services de provisions des écosystèmes forestiers
- Analyser l'impact du cyclone Giovanna sur les moyens de subsistances des petits exploitants agricoles
- Identifier l'environnement favorable pour une meilleure adaptation paysanne à la variation climatique compatible à la maintenance de ressource naturelle.

Part One

Extreme vulnerability of smallholder farmers to agricultural risks and climate change in Madagascar

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Résumé

Dans les pays tropicaux, les petits exploitants agricoles sont déjà confrontés à de nombreux risques liés à la production agricole. Le changement climatique devrait affecter de manière disproportionnée les petits exploitants agricoles et leurs moyens de subsistance; cependant, il y a peu d'informations sur leurs vulnérabilités et leurs besoins en matière d'adaptation. Des enquêtes un été menées auprès des 600 ménages à Madagascar pour caractériser la vulnérabilité des petits exploitants agricoles, pour déterminer comment ils font face aux risques et pour explorer les stratégies nécessaires pour les aider à s'adapter au changement climatique. Les Paysans Malgaches sont particulièrement vulnérables à des chocs variés sur leur système agricole en raison de leur forte dépendance de l'agriculture pour leurs moyens de subsistance, l'insécurité alimentaire chronique, l'enclavement de leurs villages et la manque d'accès à des filets de sécurité formels. La production agricole est fréquemment exposée aux ravageurs et aux maladies, et aux événements climatiques extrêmes (en particulier les cyclones), qui provoquent des pertes importants de production et de revenus et aggravent l'insécurité alimentaire. Bien que les agriculteurs utilisent une variété de stratégies de gestion des risques, elles sont insuffisantes pour empêcher leur sortie de la situation d'insécurité alimentaire. Peu d'agriculteurs ont adapté leurs stratégies agricoles face au changement climatique, en raison de leurs ressources et de leurs capacités limitées. Des appuis techniques, financiers et institutionnels urgents sont nécessaires pour améliorer la production agricole et la sécurité alimentaire des petits agriculteurs malgaches et renforcer la résilience de leurs moyens de subsistances face au changement climatique.

Mots clés: adaptation, agriculture, changement climatique, sécurité alimentaire, moyens de subsistance, Madagascar

Summary

Across the tropics, smallholder farmers already face numerous risks to agricultural production. Climate change is expected to disproportionately affect smallholder farmers and make their livelihoods even more precarious; however, there is limited information on their overall vulnerability and adaptation needs. We conducted surveys on 600 households in Madagascar to characterize the vulnerability of smallholder farmers, identify how farmers cope with risks and explore what strategies are needed to help them adapt to climate change.

Malagasy farmers are particularly vulnerable to any shocks to their agricultural system owing to their high dependence on agriculture for their livelihoods, chronic food insecurity, physical isolation and lack of access to formal safety nets. Farmers are frequently exposed to pest and disease outbreaks and extreme weather events (particularly cyclones), which cause significant crop and income losses and exacerbate food insecurity. Although farmers use a variety of risk-coping strategies, these are insufficient to prevent them from remaining food insecure. Few farmers have adjusted their farming strategies in response to climate change, owing to limited resources and capacity. Urgent technical, financial and institutional support is needed to improve the agricultural production and food security of Malagasy farmers and make their livelihoods resilient to climate change.

Keywords: adaptation, agriculture, climate change, food security, livelihoods, Madagascar

1. Introduction

Smallholder farmers constitute a significant portion of the world's population, with an estimated 450–500 million smallholder farmers worldwide, representing 85% of the world's farms (Nagayet, 2005). Smallholder farmers are also estimated to represent half of the hungry worldwide and probably three-quarters of the hungry in Africa (Sanchez, 2005). Consequently, the fate of smallholder farmers will largely determine whether or not the world succeeds in reducing poverty and hunger worldwide and meeting the Millennium Development Goals.

Across the tropics, smallholder farmers already face numerous risks to their agricultural production, including pest and disease outbreaks, extreme weather events and market shocks, among others, which often undermine their household food and income security (O'Brien et al., 2004, Morton, 2007). Because smallholder farmers typically depend directly on agriculture for their livelihoods and have limited resources and capacity to cope with shocks, any reductions to agricultural productivity can have significant impacts on their food security, nutrition, income and well-being (Hertel and Rosch, 2010; McDowell and Hess, 2012).

Climate change is expected to disproportionately affect smallholder farmers by further exacerbating the risks that farmers face. Recent studies using regional and global simulation models, for example, indicate that even moderate increases in temperatures will have negative impacts on rice, maize and wheat, which are the main cereal crops of smallholder farmers (Morton, 2007). Climate change is also expected to alter pest and disease outbreaks, increase the frequency and severity of droughts and floods, and increase the likelihood of poor yields, crop failure and livestock mortality (Morton, 2007; Kevan, 1999). As many of the countries that will be the hardest hit by climate change are tropical countries with large populations of poor, smallholder farmers (Hertel and Rosch, 2010), there is an urgent need for the global community to focus its attention on identifying adaptation measures that can help these farmers reduce their vulnerability to climate change and cope with adverse consequences.

Madagascar is a country in which understanding the vulnerability of farmers to agricultural risks and climate change is particularly important, as farmers comprise approximately 70% of the population (Minten and Barrett, 2008) and climate change impacts are expected to be significant (Tadross et *al.,* 2008). Madagascar has one of the highest poverty rates in Africa, with 81% of the island's inhabitants living on less than the international poverty threshold of $1.25 per day (PPP) and per capita gross national income (GNI) being just $430 (World Bank, 2012). In 2011, Madagascar was ranked 151 out of 187 countries assessed for the Human Development Index (UNDP, 2011b). An estimated two-thirds of the Malagasy population is considered undernourished (Dostie et *al.,* 2002) and 82% of the rural population falls below the national poverty line (INSTAT, 2011). Most farmers are smallholders (with a national average upland rice area per farmer of 1.28 ha, (Zeller et *al.,* 1999) cultivate primarily for subsistence, are chronically food insecure, and generally lack basic services, such as improved water sources and electricity (World Bank, 2012). Madagascar has suffered significant deforestation and forest fragmentation over the last 50 years (in large part owing to agriculture), with the forest cover decreasing almost 40% from the 1950s to 2000 and much of the remaining forest land being highly degraded (Harper et *al.,* 2007). In addition, much of the agricultural land is severely eroded owing to unsustainable land-use practices (Styger et *al.,* 2009).

While several studies have characterized the livelihoods of Malagasy farmers and explored factors influencing poverty and food insecurity (Barrett and Dorosh, 1996; Zeller et *al.,* 1999; Dostie et al., 2002, Minten and Barret, 2008; Raharinjanahary et al., 2010), there is limited information on the overall vulnerability of farmers to different agricultural risks (both climate and non-climate related) and the strategies that farmers use to cope with these risks. In addition, there is little information on what adaptation measures are needed to reduce farmer vulnerability in the context of climate change. Madagascar is already subjected to periodic extreme weather events, including cyclones, flooding and droughts, and it is expected that these events will intensify under climate change (Tadross et *al.,* 2008).

In this study, we explore the vulnerability of smallholder farmers to agricultural risks in Madagascar and provide recommendations on which risk management and adaptation strategies hold the greatest potential for reducing farmer vulnerability. Specifically, we characterize the vulnerability of smallholder farmers to different risks (both climate and nonclimate related), identify the risk coping and adaptation strategies used by farmers, and

highlight key adaptation needs. By increasing knowledge of the impacts of risks to agriculture and the existing coping strategies that farmers use, our study provides critical information for development organizations and donors focused on food security and poverty alleviation in rural areas of Madagascar, as well as for policymakers working on the design of both national and international strategies for climate change adaptation, agricultural productivity, and hunger and poverty alleviation.

2. Material and methods

We assessed farmer vulnerability to agricultural risks in three different landscapes of Madagascar: Ankeniheny-Zahemena Corridor (French acronym: CAZ), Nosivolo (NSV) and Mahavavy Kinkony Complex (French acronym: CMK; figure 1.1). Both CAZ and NSV are located around Madagascar's eastern escarpment and are characterized by a moist, subtropical climate. The Ankeniheny-Zahamena Corridor has one of the largest remnants of tropical rainforest in eastern Madagascar, surrounded by agricultural land. The forest is in the process of being formally gazetted as a protected area (Ministry of Agriculture, 2004; Ministry of Agriculture. 2009). The Nosivolo landscape is a diverse mosaic of agricultural land and patches of tropical rainforest in the watershed of the Nosivolo River (Ministry of Agriculture. 2004). CMK is a complex of lakes, wetlands and agricultural land, with a small area of remaining tropical dry forest in northwestern Madagascar, which experiences a dry and warm climate, with two distinct seasons (Ministry of Agriculture, 2004). In all three sites, farming is centred on rice, cassava and maize production. In CAZ and NSV, rice production on the hillsides is mainly rain fed and done using slash and burn ('tavy'), while rice in the lowland, flatter areas of these landscapes and in most of CMK is produced in paddy fields. Our study landscapes are representative of three of the four major agroecological regions (the western region, highlands and the eastern region) present in the country, but do not cover the drier southern ecosystem.

We characterized farmer vulnerability to agricultural risks using detailed household surveys and focal group discussions. In each landscape, we first met with key informants (e.g. local non-governmental organizations, mayors, chiefs of fokontany— the smallest administrative unit in Madagascar comprising one or a couple of villages—and village chiefs) to describe the project, obtain input into the proposed research, identify the main farming systems

present and begin discussion of the risks affecting agricultural production. Using this information, we selected 10 villages per landscape that were considered representative of the main farming systems present, and then randomly selected 20 households per village for interviews (i.e. 200 households per landscape and 600 households in total).

The household survey was designed to characterize farmer livelihood strategies, agricultural risks, risk coping mechanisms, perceptions of climate change and adaptation needs. Prior to applying the surveys, we reviewed the survey questions, content and terms with focal groups, and tested the survey with 20 randomly selected farmers. The final survey consisted of 197 questions, most of which were multiple choice or close-ended questions (Appendix1). We conducted the household surveys during a six-week period from November to December 2011. In each region, the survey team consisted of a lead, together with 10 locally recruited interviewers (who were native speakers of Malagasy and trained on sample design and survey techniques). The interviews were conducted in Malagasy at the participant's home or farmland, and took approximately 1 h and 45 min to complete. In each household, we conducted interviews with the self-identified head of the household (usually a man). All information from the interviews was recorded manually on data sheets by the interviewers and checked for accuracy by lead field research staff. In addition, survey results were discussed with focal groups in each landscape (consisting of 10 men and10 women) to ensure accurate interpretation of results. In the household survey, response rates of participants were high (usually more than 98%), but because the structure of the survey allowed household members to skip certain sections of the survey if these sections did not apply to the household or if they had answered in a certain way to a previous question, the sample size per answer varied and is therefore noted in the tables.

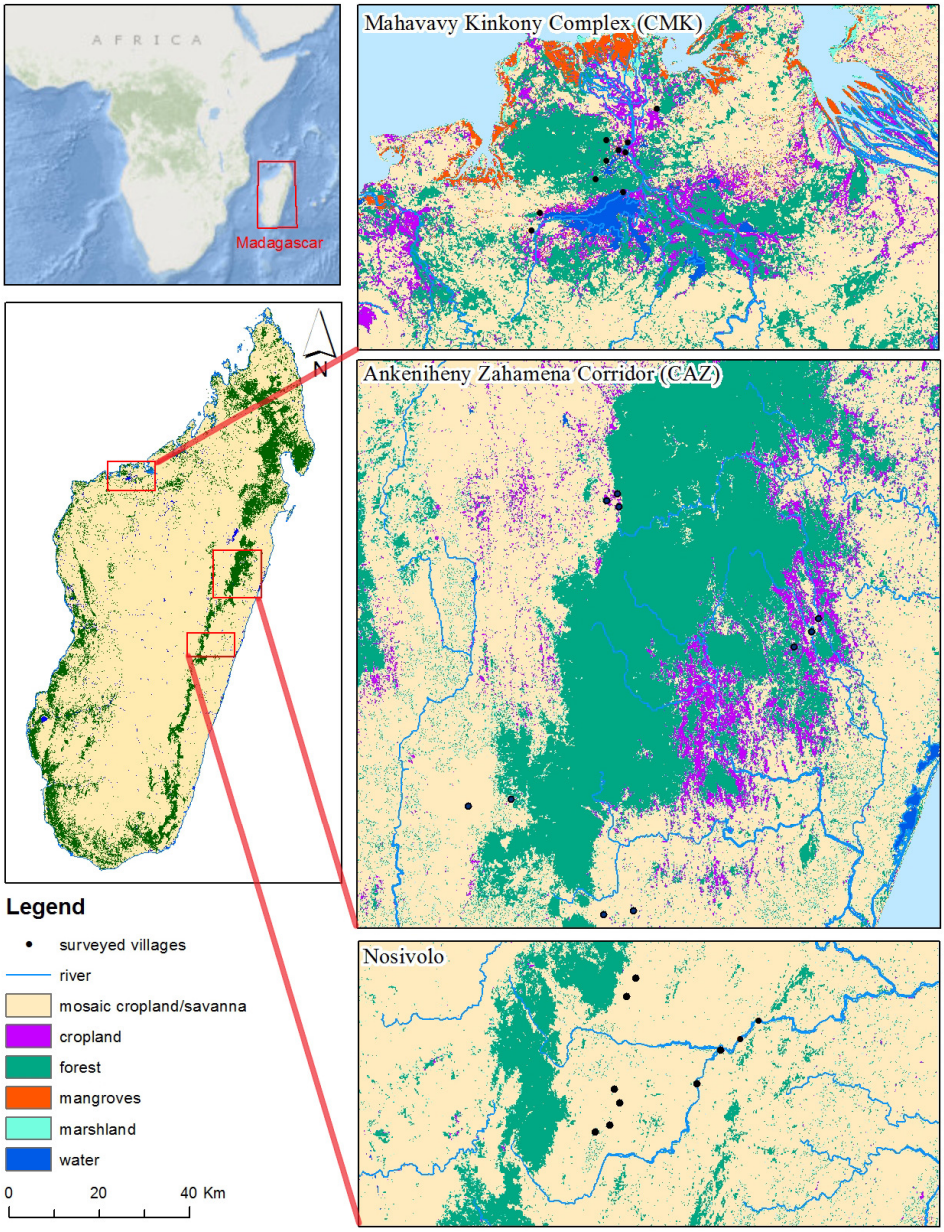

Figure 1.1. Map showing the location of the three study landscapes, the key land uses in each landscape and the location of the 10 villages per landscape (30 total), where household surveys were conducted.

All data were analyzed using either INFOSTAT v. 2012 (Di Rienzo et *al.,* 2012) or STATA (StataCorp, 2007). All data analyses were conducted on the combined data from the three landscapes. To explore which factors influenced household risks relevant to food security, we developed indices of key variables of household and farm characteristics (scaled from zero to one) and then ran Spearman correlations of each index against our variable of household food

insecurity (¼ the number of months in which farmers reported not having enough rice from their own production to feed their household in a typical year).We similarly used Spearman correlations to explore relationships between household and farm characteristics versus the number of adaptation measures each farmer had adopted.

3. Results

3.1. Household characteristics

Across the three regions, the living conditions of smallholder farmers were poor, with farmers living in small, basic houses made of local materials (*Raphia ruffa,* bamboo, *Ravenala madagascariensis* and/or mud) and most households (98%) depending on firewood for cooking and oil for light. Nearly half of the farmers obtained their water directly from rivers and an additional 17% from lakes or ponds; only 13% had access to public taps. Smallholder farmer education levels were low, with 27% of the farmers lacking any formal education and an additional 48% having only completed primary school. Seventy-one per cent of the smallholder farmers were born in the villages where they currently live; the remainders were migrants who had moved to the villages either to improve their standard of living or because of marriage. Most smallholder farmers lacked a means of transportation (only 15% owned bikes and 13% owned oxcarts), so have to walk, often several hours, to get their products to market. Just under a fifth of all households had access to mobile phones. Less than 2% of farmers had personal saving accounts or were members of a village savings account. Mean household size was 7.5 (+0.1) members.

3.2. Farming systems

Farmers typically had several plots of land, with some under tavy (slash and burn) for rice production, some plots in lowlands or wet areas for rice production, and others dedicated to other agricultural crops, such as cassava, maize, vegetables or fruits (table 1.1). In most cases, the plots of land were small, with 68% of farmers having less than 1 ha under tavy for rice production and 32% having less than 200 m2 under tavy. Rice, cassava and maize were the most common crops, cultivated by 89%, 91% and 72% of all farmers, respectively, but a subset of farmers (particularly in CAZ and NSV) also cultivated additional crops, such as bananas, beans, sweet potatoes and others. In addition, many farmers had small numbers of

livestock, particularly chickens, and also cattle, pigs and ducks. Farmers used low technology management approaches, such as intercropping (e.g. maize/beans and rice/maize), and to a lesser degree agroforestry systems and fire (particularly in tavy systems). Few farmers practiced soil conservation techniques, despite the steep slopes present. The use of agricultural inputs, chemical fertilizers, and improved seed varieties was very low and only 7% of farmers reported receiving any technical assistance on crop or livestock production.

Table 1.1. Characteristics of smallholder farming systems in three regions of Madagascar based on household surveys. Data represent the percent of households or the means and standard errors across households.

Category	N	Variable	% of households
Total area under tavy for rice production	505	< 200m^2	32
		200-500 m^2	14
		500m^2 -1 ha	22
		1-2 ha	17
		>2 ha	15
Total area under non-tavy rice production	565	< 200m^2	28
		200-500 m^2	16
		500m^2 - 1 ha	27
		1-2 ha	18
		>2 ha	11
Total area under other agricultural systems	527	< 200m^2	41
		200-500 m^2	20
		500m^2 - 1 ha	23
		1-2 ha	11
		>2 ha	5

Table 1.1. Characteristics of smallholder farming systems in three regions of Madagascar based on household surveys (Cont'd).

Category	N	Variable	% of households
Crops grown (ordered from most common overall to least common)	600	Rice	89
		Cassava	91
		Maize	72
		Bananas	53
		Beans	49
		Sugarcane	48
		Sweet potatoes	36
		Peanuts	25
		Taro	25
		Coffee	24
		Litchi	24
		Oranges	22
		Ginger	14
		Mangos	14
		Potatoes	10
Household crop diversification	600	Mean number of crops per household	6.0 ($\pm$0.14)
Use of specific agricultural practices (in decreasing order of importance)	597	Intercropping	43
		Fire	38
		Multiple cropping	37
		Irrigation	25
		Biological control	23
		Manure fertilizer	22
		Improved seed varieties	12
		Agroforestry	14
		Chemical fertilizer	9
		Soil conservation practices	6

Table 1.1. Characteristics of smallholder farming systems in three regions of Madagascar based on household surveys (Cont'd).

Category	N	Variable	% of households
Livestock ownership	600	Chickens	71
		Cattle	38
		Pigs	21
		Ducks	11
		Goats	1
Technical assistance for crop or livestock production	598		7

3.3. Livelihood strategies and food security

Agriculture was the primary livelihood activity for households in all three regions in both seasons (table 1.2, but particularly in the dry season when it provides more than 50% of all of their income. Other common sources of income included livestock production (79% of farmers) and occasional outside work (43%), primarily as agricultural labourers on other farms. In all three regions, rice and cassava (and maize in CMK) were the most important crops both for home consumption and income generation. For example, more than 85% of all households reported consuming half or more of their rice harvests, and of these 45% consume more than three-quarters of their rice harvests.

Food security was a significant problem for farmers, with 75% of the households reporting that they did not produce sufficient rice to feed their households year-round. In each of the regions, farmers reported a distinct 'lean' season (from December to March) during which more than 40% of the households lacked sufficient food (figure 1.2). This lean season occurs at the beginning of the rainy season before the rice harvest and extends for an average of 3.8 months. There was great variation across households in the level of food insecurity, however, with 27.3% lacking sufficient food for six months or more each year and 5.5% of the population suffering food insecurity year-round. Factors that were positively related to

household food security included livestock ownership (r =0.10, p =0.01), ownership of means of transportation (e.g. either an oxcart or a bicycle; r =0.15, p <0.001), household head being born in the village (r = 0.46, p < 0.01) and higher education level of the household head (r = 0.64, p < 0.0001).

Table 1.2. Household livelihood strategies and food security of smallholder farmers in Madagascar based on 600 household surveys. Number represents the % of households or the mean number per household.

	Variable	N	Variable	Total
Livelihood strategies	Sources of household income (ordered from most common overall to least):	600	Agriculture	99
			Livestock	79
			Occasional work off-farm	43
			Handicrafts	19
			Fishing	14
			Commerce (small scale)	10
			Mining	8
			Salaried permanent work	5
			Charcoal production	3
			Logging	2
	Income diversification	600	# of sources of income per household	2.8 ± 0.04
	Households selling staple crops	533	Rice	84
		473	Cassava	87
		432	Maize	61
	Percent of household income derived from agriculture during the wet season	589	<25%	27
			25-50%	41
			50% -75%	22
			> 75%	10
	Percent of household income derived from agriculture in dry season	588	<25%	17
			25-50%	22
			50% -75%	40
			> 75%	21

Table 1.2. Household livelihood strategies and food security of smallholder farmers in Madagascar based on 600 household surveys. Number represents the % of households or the mean number per household (Cont'd)

Food security	Percent of rice production used for home consumption	529		3
			25-50%	12
			50-75%	40
			75%	45
	Percent of cassava production used for home consumption	508	<25%	7
			25-50%	37
			50-75%	31
			>75%	25
	Percent of maize production used for home consumption	362	<25%	6
			25-50%	20
			50-75%	29
			>75%	45
	Household food insecurity	600	% of households who do not produce sufficient food to feed their households year round (in a typical year)	75
		600	Mean number of months that households lack sufficient food in a typical year	3.8 ± 0.1

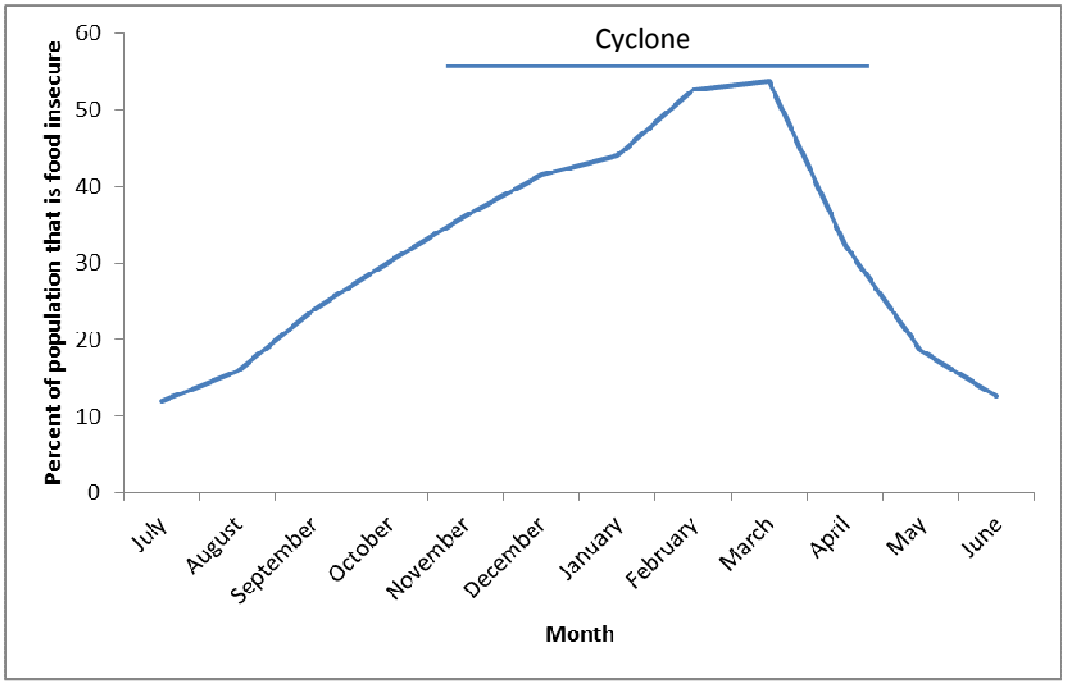

Figure 1.2. Seasonal pattern of food insecurity among smallholder farmers in Madagascar in a regular year. Data show the percent of farmers (n=600) who reported having insufficient food at different times of the year. The line above the graph represents the typical cyclone season in Madagascar and indicates the overlap between periods of food shortages and the occurrence of cyclones.

3.4. Risks to agriculture and farmer livelihoods

Smallholder farmers faced frequent risks to their agriculture, including disease outbreaks, pest damage, and crop loss during storage and occurrence of extreme weather events (table 2.3). The amount of crop lost to pests, diseases, storage problems or extreme weather events—and the accompanying income loss—was highly variable across households, with impacts ranging from mild to severe. For example, during the last cyclone 29% of farmers lost less than a quarter of their crops to the cyclone, while 10% lost more than 75% of their crops. The prevalence of extreme events was particularly notable: in the last 5 years, cyclones have affected 51% of all farmers surveyed, while severe drought and flooding have affected 68% and 44%, respectively. Extreme weather events were reported to have significant impacts on farmer food security, increasing the number of months in which they lack

sufficient food. On average, households experienced 3.8 (+0.1) months of food insecurity following cyclones, 3.4 (+0.1) months following floods and 3.2 (+0.1) months following droughts. Following the last cyclone, 89% of farmers had to rebuild the roofs or walls of their houses.

Farmers also faced risks to their livestock, including disease (affecting 14% of households), theft (7%) and drought (2%), though the per cent of households affected by these risks was much smaller than that of households experiencing risks to agriculture. Other risks to farmer livelihoods were related to market issues, such as high volatility in market prices for agricultural products (reported by 90% of farmers), large increases in the prices of agricultural inputs (60%), low prices for their products (58%) and problems getting products to markets owing to impassable roads (37%).

3.5. How farmers cope with food insecurity and income loss

Farmers reported using a variety of coping strategies to deal with food insecurity. When farmers experience food shortages, they respond by eating smaller meals, eating fewer times a day, changing their diet (principally from rice to cassava or maize; table 1.4) or supplementing their food supplies by harvesting wild yams (Dioscorea species) and other tubers in nearby forests. Farmers also supplement their food supplies by purchasing rice from market and routinely sell household assets (particularly chickens) or send household members to get outside employment (as an agricultural labourer on another farm) to obtain income to buy food. Social networks were also critical, with 20% of households indicating that they borrowed money from friends, neighbours or local organizations to buy food, and 10% of families receiving food from neighbours or relatives. Interestingly, only 1% of the farmers reported receiving food aid from local institutions. Farmers also reported helping each other to collect raw materials (palms, bamboo and other plants for thatch and timber) and rebuild damaged houses following cyclones.

3.6. Adaptation strategies for extreme weather events and climate change

There was a general perception among the smallholder farmers that climatic conditions have changed over the last 10 years. Commonly observed climatic trends included higher

temperatures (reported by 95% of farmers), lower rainfall (94%), more variable rainfall (95%), greater variability in seasons (89%) and stronger cyclones (58%). Only a subset of farmers reported having made changes in their farming practices to either reduce their future vulnerability to droughts and floods or to accommodate long-term shifts in climatic conditions (table 1.5). The most common adaptation strategies ranged from planting new crops or new varieties, to better water management, to the implementation of practices (e.g. soil conservation practices) to improve agricultural sustainability, to measures for managing water resources. However, the perceived effectiveness of these strategies was very low, with roughly 50% of all farmers indicating that their adaptation strategies for drought and flooding were not effective. The number of adaptation measures adopted per household was positively correlated with greater sources of income ($r=0.25$, $p < 0.001$), farmer education levels ($r = 0.19$, $p < 0.001$), being born in the village ($r= 0.16$, $p <0.001$), the diversity of crops ($r =0.4$, $p < 0.001$) and management techniques used on farm ($r= 0.46$, $p< 0.001$) and livestock production ($r= 0.16$, $p <0.01$), and negatively correlated with household food insecurity ($r= 0.09$, $p =0.03$).

4. Discussion

3.1. Farmer vulnerability

Across the regions studied, smallholder farmers live in precarious conditions and are intrinsically vulnerable to any shocks that affect their agricultural systems. As in much of rural Madagascar and other parts of Africa (Randrianarisoa et *al.,* 2001; Bryan et *al.,* 2009), the farmers live in rustic houses, lack electricity and running water, own few assets and rely on natural ecosystems for drinking water, firewood, wild foods and materials for household construction. Agriculture is the mainstay of farmer livelihoods, serving both as the primary source of household food and principal means of income generation. Consequently, the fate of these smallholders is closely interwoven with that of farming.

Malagasy farmers are particularly vulnerable to any reductions in crop productivity for a variety of reasons. First, the farmers cultivate very small parcels of land (less than 1 ha), dedicate most of their land to crop production for household consumption and obtain low crop yields, which are insufficient to meet household needs, let alone provide surplus for sale.

In focal group discussions, farmers reported obtaining rice yields of only 0.7–0.8 tons ha–1, which is even lower than the national (low) average of 2.1 tons ha–1 (Roubard, 1997). The low (and declining) yields in our study regions probably reflect the limited use of inputs (fertilizers, pesticides, improved seed varieties), the lack of animal traction, the use of low technology practices, the use of suboptimal land for rice, the prevalence of slash and burn rice production, and land degradation—all of which have been identified as constraints to agricultural productivity elsewhere (Randrianarisoa *al.,* 2001; Minten et *al.,* 2007).

A majority of households in all three landscapes are chronically food insecure, which makes them extremely vulnerable to any climate or non-climatic shocks that further reduce agricultural production and food availability. Even in normal years, three-quarters of the farming households lack sufficient food to feed their families and spend, on average, 3.8 months without sufficient food. Food pressure is most acute in the months immediately prior to the main rice harvest.

Table 1.3. Summary of the risks to rice production experienced by smallholder farmers and the impacts of these risks on rice yields and household income (as reported by farmers). Numbers represent the % of farmers experiencing this problem or the means (+SE).

Agricultural risk	**n**	**% of farmers affected**	**Frequency of risks (mean number of occurrences in last 5 years)**	**% of crop yields lost due to risks**				**% reduction in household income due to risk**			
				<25%	25-50%	50-75%	>75%	<25%	25-50%	50-75%	>75%
Significant disease outbreak	539	47	1.6 (± 0.08)	56*	29*	15*	--	10*	32*	41 *	15*
Severe pest damage	539	81	3.1 (± 0.09)	--	--	--	--	--	--	-	--
Loss of crops during storage	539	36	1.3 (± 0.09)	88	10	2**	--	--	--	--	--
Cyclones	524	51	1.2 (± 0.1)	30	29	30	26	39	30	21	10
Severe flooding	524	44	1.2 (± 0.1)	40	35	20	5	40	34	17	8
Severe drought	524	68	1.8 (± 0.1)	23	42	27	9	35	35	22	8

*Note: impacts of pests and diseases on crop yields and income levels were assessed jointly, due to difficulties of attributing impacts to one or the other.

** These numbers (for crop storage) refer to losses of >50%.

Table 1.4. Percent of households using different coping strategies to deal with reduced agricultural production, food insecurity and income loss in three regions of Madagascar (ordered from most to least common). Sample size ranged from 596-600 households per question.

Coping strategies	**Total**
Ate less food	81
Reduced number of meals/day	60
Purchased food	67
Changed diet	51
Sold assets to buy food	42
Borrowed money	20
Received food from relatives	16
Increased consumption of wild plants and animals	14
Sent older children away to work	9
Received food from neighbours/community	8
Took boys out of school	7
Took girls out of school	6
Made children work more on the farm	6
Sent an adult household member to get an outside job	6
Leased their land to other farmers	1
Received food aid from organization	1

This seasonal pattern of food insecurity occurs across the country, with an estimated additional one million Malagasy falling below the poverty threshold during the period of acute food shortage, joining the nine million who are poor year-round (Dostie et *al.,* 2002). The lack of sufficient food has significant livelihood impacts, including increased rates of malnutrition and child mortality (Dostie et *al.,* 2002).

Another factor that increases farmer vulnerability is the remoteness of farm villages and lack of adequate road infrastructure. Across the three regions, roads are in a poor state and unevenly distributed, with many villages lacking roads that connect them to other villages. Even the main roads are often accessible only during the dry season. The livelihood implications of this isolation are significant, as farmers have difficulties getting their products to markets as well as obtaining agricultural inputs; in addition, farmers generally have to pay higher prices for agricultural inputs in remote areas, reducing their profit margins (Minten et *al.,* 2007).

A final set of factors that exacerbate farmer vulnerability is that most households lack access to formal safety nets to which they could turn in times of need. Most of the smallholder farmers remain outside a formal credit or banking system, lack capital and are unable to access credit or loans (less than 2% of the farmers surveyed had either a personal savings account or village savings accounts).There are no developed insurance markets and instead farmers rely on informal support systems, borrowing money or food from family or friends. In addition, although there are numerous local NGOs working in the three regions, there is no formal extension service and only 7% of the farmers currently receive any technical support. Farmers are further constrained by having limited access to agrometeorological or market information (only 19% of the households have mobile phones), which could help inform farm management decisions, such as the choice of crops, planting dates and management strategies, and which could serve as early warning systems for floods and cyclones (Vogel and O'Brien, 2006).

3.2. Risks and risk coping strategies

In all three regions, smallholder farmers face multiple, recurring and substantial risks to their agricultural production and livelihoods— including risks owing to pest and disease, risks related to weather events and climate change, and those related to market access/price volatility. Farmers routinely face significant pest (particularly mice) and disease outbreaks (particularly rice blast, *Pyricularia oryzae*) and the accompanying crop and income losses, while highly variable, can be substantial (e.g. 15% of farmers reported losing more than half of their crop to pests and diseases).

In addition, farmers are frequently subjected to extreme weather events, which result in crop and livestock losses, as well as damage to agricultural fields, roads and homes. Cyclones are a prominent feature of Madagascar's climate, occurring from November to May, with an average of three to four cyclones per year (Tadross et *al.,* 2008; Government of Madagascar, 2008). Cyclones have particularly detrimental impacts on smallholder farmers because the peak cyclone season (January–February) occurs during the 'lean season' when farmers are already experiencing food shortages. In addition, cyclones often completely devastate crop yields, leaving farmers without the means to generate income. As in other regions where cyclones are common (Hahn et *al.,* 2009), the recurring nature of cyclones makes it

extremely difficult for farmers to move out of poverty, as there is often little time for farmers to rebuild their houses, replant their crops and recover before another cyclone hits.

Farmers are also affected by problems of market access and price volatility. Despite the fact that most farmers in the study regions do not produce enough rice to feed their families, 84% of households sell some of their crop immediately following the harvest to cover the costs of inputs and basic household needs. Later in the year, when their rice reserves run out, these same families typically buy back rice in the market, often at higher prices—a phenomenon that is common across Madagascar (Minten and Barrett, 2008). Rice prices are generally the lowest immediately after the harvest, and the highest during the lean season when farmers buy rice back to feed their families (Barrett and Dorsh, 1996), thereby reducing the ability of farmers to purchase food. Related problems include difficulties of farmers getting their produce to market, owing to the lack of road infrastructure as well as low demand for some products.

Farmers in all three regions use a variety of coping strategies to deal with impacts on their agricultural production and food security. One of the most common strategies for households is to consume less food or to switch their diet from rice to cassava and other tubers. A subset of farmers also relies heavily on wild foods from communal forests to supplement their diets. Wild yams are particularly valuable for farmers because their harvest season coincides with the period of rice shortage and they can be easily stored for long periods of time once they have been processed (Ackermann, 2004). Farmers also find means of generating extra income so that they can purchase food in the market, often selling small livestock (e.g. chickens) or working as agricultural wage labourers on their farms. Last, but not least, farmers turn to relatives or friends for support—to borrow money, obtain help in rebuilding houses or borrowing food. These social relationships are particularly critical given the lack of formal safety nets. Studies of smallholder farmers elsewhere have reported a similar set of coping strategies (Jacoby and Skoufias, 1997; Dercon, 2002; Morton, 2007; Hahn et *al.,* 2009). However, a few strategies that are common elsewhere— such as receiving food aid, participating in food for work programmes, receiving support from local organizations or migrating to another area—were only rarely reported by farmers in our study regions.

Table 1.5. Management practices that smallholder farmers have put in place to decrease their vulnerability to drought, flooding and changing climatic conditions. Percentages refer to the percent of those farmers who made this change in response to a given risk

Agricultural risk	**n**	**Types of changes made by farmers in response to different risks**	**% of farmers**
Drought	432	Changed timing of crop planting	28.2
		Changed crops grown	16.0
		Changed crop varieties	9.3
		Changed location of crop fields	7.2
		Built a water harvesting system for crops	3.7
		Installed an irrigation system	2.1
Flooding	297	Replanted crops after flooding subsided	22.2
		Built diversion ditches to remove water from fields	16.8
		Changed timing of crop planting	11.1
		Changed crop varieties	10.1
		Stopped farming the land that was flooded	9.4
		Changed crop type	8.4
Climate change (generally)	543	Increased use of intercropping	22.5
		Built a communal granary or food storage system to store crops	18.8
		Changed the location of fields	15.1
		Diversified production system by incorporating trees	13.1
		Implemented soil and water conservation practices	11.2
		Changed crop varieties	11.0
		Changed type of crop	9.6
Changes in water availability due to climate change	544	Built ditches to direct water or floods away from certain areas	18.2
		Developed irrigation system for crops	11.6
		Built a water harvesting scheme for crops	8.2
		Built a water harvesting system for livestock	2.0
		Built a water harvesting system for domestic consumption	1.1

While these coping strategies clearly help to mitigate impacts on farmer livelihoods, the fact that most farmers suffer chronic food insecurity suggests that these coping strategies are insufficient. In addition, there are limits to how much different coping strategies can be successfully used. For example, off-farm employment opportunities are often restricted to the months when fields need to be planted and opportunities may be limited. Harvesting wild

yams to supplement food supplies may be unsustainable in the long run, if farmers overharvest them or if the forest ecosystems are degraded. In addition, if all households in a given village are impacted by a cyclone, farmers are unable to turn to neighbours or family members living in the same region to borrow money, as these households will similarly be in need of support. There is therefore an urgent need to provide coping strategies and safety nets, which can better alleviate chronic food insecurity, both in regular years and in times of stress.

3.3. Climate change and adaptation needs

Climate change will likely have significant livelihood impacts on the smallholder farmers in all three regions and further exacerbate food insecurity and poverty. Climate models suggest that Madagascar will experience an increase in mean temperature of 1.1–2.68C this century, as well as increases in rainfall across the island in summer and increases in rainfall in winter everywhere except the southeast coast (Tadross et *al.,* 2008). The destructive force of cyclones is also expected to increase (Tadross et *al.,* 2008). In addition, most climate models show a projected negative impact of climate change on crop productivity in Africa models (Challinor et *al.,* 2007; Schlenker and Lobell, 2010). For example, a recent synthesis of models of the projected impacts of climate change on agriculture indicated that maize and cassava production will be significantly reduced by midcentury (with mean estimates of an aggregate 22% reduction in mean maize yields across sub-Saharan Africa, and an 8% reduction for cassava; (Schlenker and Lobell, 2010). These changes will probably place farmers under additional stress, both owing to direct reductions in agricultural productivity and through impacts on human health, infrastructure and availability of firewood and other ecosystem services on which the poor depend (Morton, 2007; Hertel and Rosch, 2010).

In all three landscapes studied, most farmers reported that they had noticed changes in climatic conditions over the last 10 years, with more than 90% reporting increase in temperature and changes in rainfall patterns. It is not possible for us to determine whether or not these perceived changes are accurate, owing to the lack of long-term climatic data for these landscapes. However, it is clear that farmer's perceptions of climate change, regardless of whether these are correct or not, are already causing some farmers to change their agricultural practices and have important consequences for their livelihoods. Other studies

have similarly shown that farmer perceptions of climate change are an important factor driving the adoption of different livelihoods strategies and adaptation measures (Thomas, 2007; Hassan and Nhemachena, 2008; Bryan et *al.,* 2009).

Interestingly, while most Malagasy farmers already perceive the impacts of climate change, as in other parts of Africa (Bryan et *al.,* 2009), only a subset (21%) have changed their farming systems in response to these changes. The limited uptake of adaptation strategies by farmers is probably due to the high levels of household food insecurity, which make it risky for farmers to adopt new strategies that may affect their agricultural production and food availability. In addition, most farmers in our region simply lack the resources needed to implement adaptation measures, as has been found in other regions (Madison, 2007; Bryan et *al.,* 2009). The fact that the use of adaptation measures was positively correlated with farmer education level, use of diversified agricultural practices, diversified cropping systems and livestock ownership indicate that farmers who are better educated and already have more diversified systems are more likely to be willing to adopt new strategies. Other studies have similarly highlighted the importance of educational level, wealth, access to credit and information, extension services, safety nets, resources and adequate agricultural inputs and technologies in increasing the probability of uptake of adaptation measures by smallholder farmers (Ziervogel et al., 2006; Madison, 2007; Bryan et *al.,* 2009).

3.4. Policy options for reducing farmer vulnerability in a changing climate

Farmers in our study regions are in a vicious cycle of food insecurity due to low yields, regular shocks that reduce agricultural yields and inadequate coping strategies, and this situation is likely to be further exacerbated by climate change. An inevitable question given the bleak outlook is whether farming is really a viable option for improving farmer livelihoods, or whether policymakers should focus instead on developing alternative employment strategies for these rural populations. In the study areas—and in most rural areas of the country—there are few employment alternatives available to farmers and the poor infrastructure and lack of basic services make it extremely difficult to promote nonfarming activities, so farmers will inevitably continue to farm in the absence of other options. In addition, while migration of farmers from rural areas to the urban areas in search of employment does occur, it is unlikely that the cities can successfully absorb the estimated

70% of the population that currently depends on farming for their livelihoods. Efforts to improve the livelihoods of smallholder farmers, therefore, will necessarily need to focus, at least in the near term, on increasing agricultural productivity and making farmer livelihoods less vulnerable to climate change and other risks.

Particular attention must be paid to raising agricultural productivity, as this could make a significant difference in food insecurity and poverty levels, both by increasing the total food availability to households and improving household income generation (Dostie et *al.,* 2002; Sanchez and Swaminathan, 2005). Agricultural growth has been shown to be 2.2 times as effective at reducing poverty as growth in non-agricultural sectors (Christiansen et *al.,* 2006), indicating the critical role that improving agricultural productivity should play in development strategies. Efforts to improve agricultural productivity should target not only rice—the staple of Malagasy diets—but also the production of secondary food crops, such as maize, cassava and other tubers, as these are the foods that the rural poor turn to during the lean season.

There are many potential options that could increase the agricultural production and improve the livelihoods of Malagasy farmers. These range from high-level transformations (such as changes in agricultural policies, economic development policies, poverty reduction strategies, public safety nets, market reforms, institutional arrangements and governance structures; (Barrett and Dorosh, 1996; Zeller et *al.,* 1999; Randrianarisoa and Minten, 2001; Dostie et *al.,* 2002; Minten and Barrett, 2008; Hertel and Rosch, 2010) to more local-level actions, which aim to directly improve farmer productivity. While systematic and transformational changes in policies and governance are urgently needed to address Madagascar's high poverty and chronic food insecurity, these changes are extremely difficult to achieve and fall beyond the scope of our paper. Our focus here, instead, is on specific technical options, which we believe hold promise as low-cost, feasible and relatively fast opportunities for improving agricultural productivity on farms, which can be pursued even in the context of unfavorable policies and institutional arrangements.

Options that have been shown to be effective in increasing agricultural productivity elsewhere in Africa include facilitating access to improved seed varieties, fertilizers, irrigation and other inputs (Minten et *al.,* 2007), improving road infrastructure and access to markets (Dercon, 2002; Barrett et *al.,* 2004), providing greater technical support and extension services to farmers (Madison, 2007; Bryan et *al.,* 2009), and facilitating access to

timely climate information, which could be used to inform the choice of crops, planting dates and management strategies (Sanchez and Swaminathan, 2005; Vogel and O'Brien, 2006), among others. Given the high poverty levels in Madagascar and limited public expenditure, some of these options (such as improving the road network in rural areas or increasing the distribution and use of farm inputs), though desirable, are unlikely to be feasible in the short term.

Our research suggests four potential areas for policymakers to pursue that could help to increase agricultural productivity and improve livelihoods in the short term. First, there is an urgent need to improve farmer extension services to provide technical information and training on the best management practices for planting, harvesting and crop storage, to facilitate the adoption of new management practices and to encourage farmer to- farmer learning. Strengthening extension services has been shown to be particularly effective at convincing farmers to change farming practices in response to climate change (Madison, 2007; Bryan et *al.,* 2009). Our results show that only7% of farmers in our study regions currently have access to technical support on agriculture and that the adoption of management practices aimed at reducing vulnerability to climate risks is low, despite the prevalence of these risks. These results indicate that there is significant scope for relatively low-cost farmer extension services to improve the uptake of such practices and provide ongoing technical support. For example, changes in crop planting schedules, management practices and varieties used, as well as the diversification of crops planted, are all low-cost options for reducing agricultural risk, which could be widely promoted through extension services and communication campaigns (FAO, 2010). Careful screening of these strategies and participatory action-oriented research with farmers will be needed to jointly identify and implement adaptation options that are feasible and effective and to ensure that these strategies do not have any negative or unexpected impacts on farmer livelihoods (Howden, 2007; FAO, 2010).

The second low-cost opportunity for policymakers and donors is to invest in small-scale infrastructure, such as improved irrigation systems or crop storage facilities, which can help farmers to increase production and better protect their harvests. Smallholder farmers in Madagascar are very keen to build local infrastructure but rarely have the necessary capital to finance these activities. There are many examples in Madagascar of grants and even small loans being used to help with such investments that result in important increases in areas under cultivation and agricultural yields (World Bank, 2008; USAID, 2010). Governments

and organizations working in remote areas should seek to further promote such small-scale infrastructure through the development of small-scale grants and credit to farmers or local farmer associations.

The third option for improving farmer livelihoods is to increase access to credit and safety nets during lean periods and following catastrophic events, such as extreme weather events or disease and pest outbreaks. In these extreme situations, many farmers currently depend on informal support from families and friends, as formal safety nets are lacking. There is a critical need to establish formal safety nets and also strengthen informal safety networks to ensure that farmers can access support when they need it. In addition, more innovative solutions are needed to facilitate access of farmers to financial services in terms of need. New services, such as mobile telephone payment systems that are beginning to be available even in remote areas, provide an important new, cheap and secure way for family and friends to exchange money even when they are not physically close to each other. Governments should work with the private sector mobile telephone companies to improve mobile coverage and access to such services. Village savings and loans groups in which members pool resources and lend to members in need are also a low-cost solution that could help to reduce the worst impacts of the lean season or extreme weather events, while creating local funds that farmers can tap into for other development activities (Heltberg et al., 2009; Bhattamishra and Barrett, 2010).

The final priority for policymakers is to safeguard the natural ecosystems that smallholder farmers use as safety nets. Forests, wetlands, rivers and other natural areas provide critical ecosystem services to Malagasy smallholder farmers, including the provision of firewood and charcoal, water, wild yams and materials for house construction (Thomas and Twyman, 2005; Hannah et *al.,* 2008), among others. These services are important year-round, but particularly following catastrophic events when farmers turn to the forests for food and materials to rebuild their damaged homes. Efforts that conserve, restore or sustainably manage these natural ecosystems are therefore crucial for sustaining farmer livelihoods

5. Conclusion

Our research has highlighted the precarious condition of smallholder farmers in Madagascar, their high exposure to risks and the urgent need to reduce both their current and future vulnerability to these risks. Increasing the productivity and resilience of smallholder farming systems is a huge challenge that will require significant and sustained technical, financial and political support and action at both the national and local levels. However, a handful of low-cost and local approaches—such as revitalizing farmer extension services, implementing small-scale local infrastructure projects with farmers, strengthening informal safety nets and safeguarding natural ecosystems—could go a long way towards beginning to address this critical challenge and improving the livelihoods of smallholder farmers across the country.

Part Two

Farmer adaptation to climate change and use of forest products in the Ankeniheny Zahamena Corridor'

Zo Lalaina Rakotobe, Celia A. Harvey, Jean Chrysostôme Rakotondravelo, Hery Razafimahatratra and Andriambolatsoa Rasolohery

Résumé

Les écosystèmes forestiers fournissent des biens et services aux populations rurales pour leur subsistance. A Madagascar, environ 85% de la population rurale utilisent directement les produits forestiers comme bois de construction, bois de chauffe ou comme nourriture sauvage, ou en font des sources de revenus. Toutefois, ces populations dépendantes des forêts sont confrontées à deux menaces majeures et interreliées : le déclin du couvert forestier et le changement climatique. Quand les phénomènes climatiques extrêmes (comme les cyclones ou la sécheresse) affectent les populations rurales, elles ont souvent recours à la forêt pour de nouveaux matériaux pour reconstruire leur habitation, ou de la nourriture d'appoint durant les périodes d'insécurité alimentaire. Toutefois, la perte et la dégradation des forêts actuellement en cours menacent la viabilité de cette stratégie d'adaptation. L'objectif de cette étude était de comprendre l'importance du support que les écosystèmes forestiers apportent pour les petits agriculteurs dans les zones reculées pour faire face aux impacts du changement climatique, et d'explorer dans quelle mesure les changements dans les conditions et l'étendue des forêts affectent cette stratégie d'adaptation. Nous avons collecté des informations sur l'utilisation des produits forestiers, l'importance des forêts comme stratégie d'adaptation, et les changements des conditions des forêts pour les 10 dernières années, en faisant une enquête auprès de 400 ménages dans 10 villages dans les régions Alaotra Mangoro et Atsinanana, dans le Corridor Ankeniheny Zahamena. Presque tous les répondants (97%) ont mentionné qu'ils utilisent les produits forestiers pour leur mode d'existence durant une année normale, et que leur dépendance vis à vis des forêts augmente après les phénomènes climatiques sévères. Par exemple, les populations locales dépendent des forêts pour reconstruire les maisons endommagées par les cyclones, et y récoltent de la nourriture sauvage quand les champs de culture sont endommagés par les vents violents ou les inondations. En outre, tous les répondants ont mentionné qu'ils ont besoin de plus de champs de culture après les cyclones et pratiquent la culture sur brûlis pour étendre leurs champs actuels. Le recours aux forêts pratiqué par les agriculteurs pourrait être une stratégie efficace à court terme, mais non durable pour le moyen et le long terme, étant donné le déclin actuel de la couverture forestière. Les stratégies pour renforcer la résilience des communautés rurales ne seront donc couronnées de succès que si en même temps, elles conservent les forêts dont celles-ci dépendent fortement.

Summary

Forest ecosystems provide goods and services to rural people for their livelihoods. In Madagascar, about 85% of the rural population uses forest goods and services as a source of household income, firewood, timber and wild foods. However, these forest-dependent people face two major and intertwined threats: the decline of forest cover and climate change. When extreme weather events (such as cyclones or droughts) affect rural populations, they often turn to the forest for new materials to rebuild homes or for emergency foods to sustain them during periods of food insecurity. However, the ongoing loss and degradation of forests threatens the viability of this coping strategy. The objective of this study was to understand the importance of forest ecosystems in helping smallholder farmers in remote areas cope with the impacts of climate change, and to explore how ongoing changes in the condition and extent of forest are affecting this coping strategy. We collected information on the use of forest products, the importance of forests as a coping strategy, and the changes in the forest condition over the last 10 years, using a survey of 400 households in 10 villages in the Alaotra Mangoro and Atsinanana regions in the Ankeniheny-Zahamena Corridor. Almost all respondents (97%) mentioned that they have used forests products for their livelihoods in normal years and that their dependence on forests increases after severe climate events. For example, local people depend on forest products to rebuild houses damaged by cyclones, and gather wild food in the forests when cropland was damaged by strong winds or flooding. In addition, all respondents mentioned that they use slash and burn to establish new croplands following cyclones. The dependence of farmers on forests as part of their coping strategy may be effective in the short term, but is unsustainable in the medium and long term, given the ongoing decline in forest cover. Strategies to enhance the resiliency of rural communities will therefore only be successful if they also conserve the forest on which these communities strongly depend.

Key words: *Adaptation, climate variability, ecosystem services, forest, and smallholder farmers.*

1. Introduction

About 1.6 billion of worldwide population depends on forests ecosystem services for their livelihoods (Walter 2001, Ticktin, 2004; UNDP, 2011a). A large proportion of them are smallholder farmers (FAO, 2014) who represent more than a billion of worldwide poorest people (FAO, 2012). Several studies have indicated that forests can a role of poverty alleviation for poor people and that they can serve as a source of forest products for gap filler (petty cash) and savings (Sunderlin et al., 2003). In Madagascar, it is estimated that about 85% of rural people rely on forests to support their daily lives, with forests serving as source of incomes, wild food and other non-forest timber products, tools for production, and croplands (Styger et *al.,* 2007; MEF, 2014).

However, forest-dependent people in Madagascar face two major threats: the ongoing decline and degradation of forest cover and climate change, which threatens their livelihoods (Ratsimamanga et Bettencourt, 2002; Bhatta et *al.,* 2015). In many regions, forests are declining due to high demand for forest products, lands, and agricultural production (Sunderlin et al., 2003; MAE, 2007; Styger et *al.,* 2009). In Madagascar, forest cover has declined at an annual rate of 0.4% or 36,000 ha of forest per year from 3005 to 2010 (ONE et *al.,* 2013). This loss of forest has significant impacts on rural communities who heavily depend on forest ecosystem services for their livelihoods (Sunderlin et al., 2003; Harvey et *al.,* 2014).

Climate change poses an additional threat to rural communities. Madagascar is highly vulnerable to climate change due to its high level of poverty and lack of resources (Maplecroft, 2011, Kreft and Eickestein, 2014). Climate variability already affects most smallholder farmers and impacts their livelihoods and crop production (MEEF, 2007; International Resources Group, 2008; Harvey et *al.,* 2014). Smallholder farmers use a variety of strategies such as crops diversification and non-farming strategies (e.g., off-farm work and the use of forest products for subsistence) to cope/adapt with these risks (Dinar et al., 2008, Balama et al., 2013). However, these coping strategies are not sufficient to cope with climate change (Harvey et al., 2014).

In Madagascar, there is little information about the role of forest ecosystem services in helping smallholder farmers cope with climate change. While several studies highlight the loss of forests due to smallholder farmer agriculture and use of slash and burn (‘tavy’), there

is much less information in the importance of these forests in helping farmers deal with climate change.. In addition, the existing national strategies for climate change (PANA and PANLCC) do not consider the role of forests in improving smallholder farmers' resiliency to climate change. A better understanding of the importance of forests to rural community livelihood and coping strategies is needed to inform the development of the national action plan for climate change adaptation and the National Strategy for Climate Change.

This study aims to show the importance of forest provisioning ecosystem services in improving the resiliency of smallholder farmers to climate change, and to identify ways in which the resiliency of rural communities can be enhanced without further degrading forest ecosystems. Its specific objectives are to assess and analyze trends in the use of forests by smallholder farmers over the last year, to document the perception of smallholder farmers on how the availability of forest products has changed over the last 10 years (from 2001 to 2011), to draw out the importance of the natural resource and its ecosystem services to the smallholder farmers' resiliency in Madagascar, and to provide recommendations to improve the resiliency of rural people while ensuring the conservation of forest ecosystems on which they rely.

2. Materials and methods

2.1. Description of the study sites

We selected four municipalities or communes in the Corridor Ankeniheny Zahamena (CAZ) to conduct this study: Morarano and Beforona in the Alaotra Mangoro region, Anjahamany in the Tamatave II region, and Didy in the Alaotra region. From these municipalities, we randomly selected 10 villages (Figure 2.1; Table 2.1) to conduct the survey. Beforona, Anjahamany, and Morarano are located in the bioclimatic humid region and Didy is located in the bioclimatic sub humid region (Cornet, 1974). The population is mainly composed by the Betsimisaraka in the Eastern part and Sihanaka in the western part of the corridor. The Sihanaka is an ethnic group that used to cultivate rice and live near Alaotra Lake. Their livelihoods are based on planting rice in the wetlands and fishing in the lake. Most of their houses are made with mud or bricks. The Betsimisaraka is an ethnic group from the eastern coast of Madagascar that practices slash and burn for agriculture. Most of their houses are made with local materials such as Ravinala (*Ravinala madagascariensis*).

The forest ecosystems within the Ankeniheny Zahamena corridor are mainly composed by dense humid evergreen rainforest within low and mid elevation, from 0 to 1800m of altitude (Humbert, 1955; Faramalala, 1995; Du Puy and Moat, 1996; MEF, 2014).

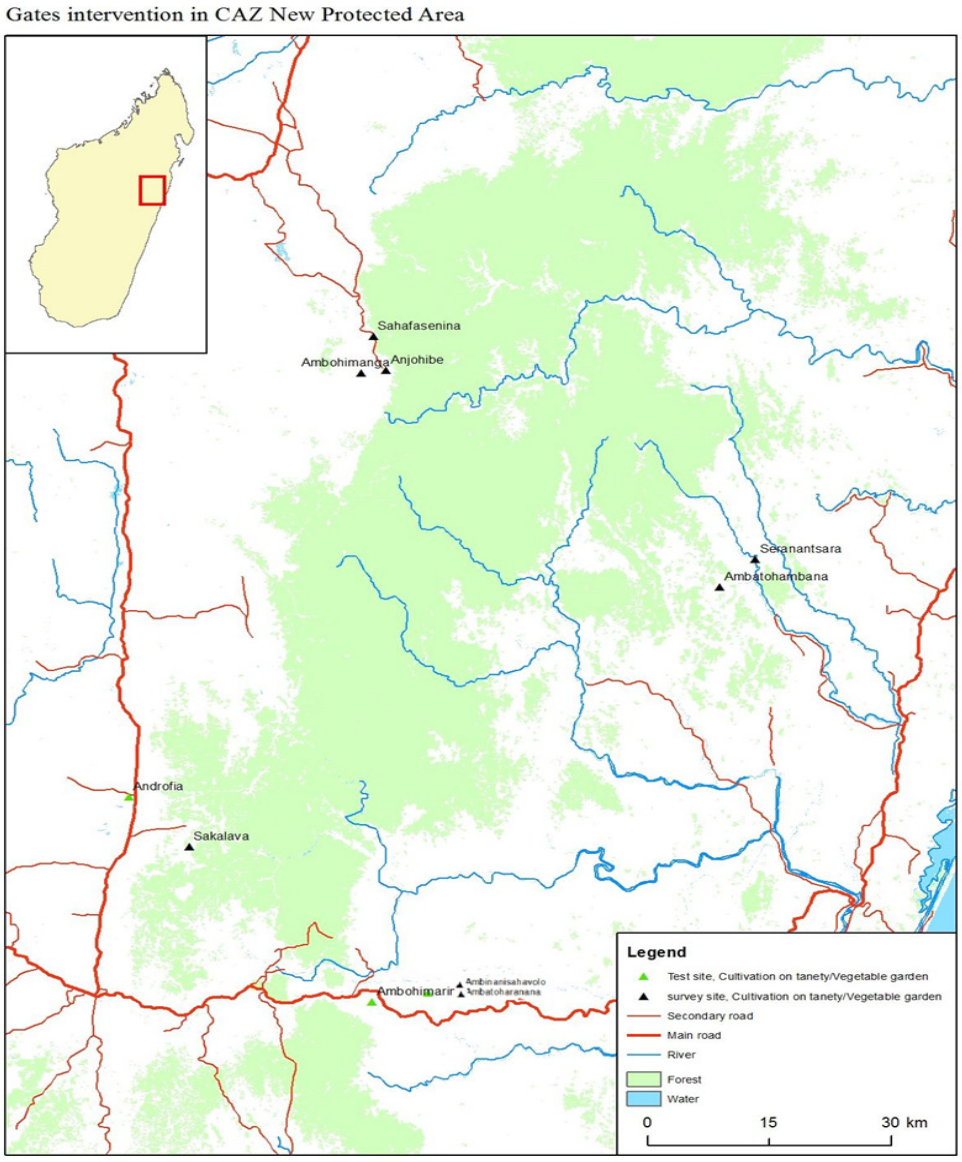

Figure 2.1. Map showing the ten villages in the Ankeniheny Zahamena Corridor in which the use of forest products in farmer coping strategies was assessed.

Table 2.1.Characteristics of the ten villages studied in the Ankeniheny Zahamena Corridor, including information on population size, topography and main crops grown.

Regions	**Rural municipalities**	**Fokontany/ Village**	**Population size (and number of households)**	**Topography of croplands**	**Main crops**
Alaotra Mangoro	Didy	Ambodimanga (Ambohijanahary)	200 (50 hh)	Flat land (wetland and Baiboho or fertile flatland	Irrigated rice, corn, cassava, beans
		Anjohibe	250 (65 hh)	Flat lands	Irrigated rice, corn, cassava
		Sahafasenina	523 (120 hh)	Flat lands	Irrigated rice, corn, cassava,
	Beforona	Ambatoharanana	480 (100hh)	Lowlands	Rain fed rice, ginger cassava,
		Ambinanisahavolo	420 (50 hh)	Lowlands	Rain fed rice, cassava, and ginger
		Ambohimarina	450 (70 hh)	Low lands	Rain fed rice, ginger, cassava
	Morarano	Androfia	102 (17 hh)	Flat land	Irrigated rice, corn, cassava
		Sakalava	100 (20 hh)	Low land and flat land	Irrigated and rain fed rice, corn, cassava
Antsinanana	Anjahamana	Ambatohambana	846 (180 hh)	Flat land and high land	Irrigated and rain fed rice, corn, cassava and cloves
		Seranantsara	307 (64hh)	Flat land	rain fed rice, corn, and cloves

2.2. Data collection of the use of natural resources

Sampling process

Prior to the village selection, we visited the mayors from each targeted municipalities to explain the objective of this study and to gather general information about their villages, the type of farming system, and other information that we used for checking the accuracy of data. For the household survey, we randomly selected 20 households per village (i.e., 20 household/village X 10 villages = 200 households total). As information from individual based on gender was useful for the analysis, we interviewed separately both spouse and wife in the same household. The sampling size was therefore 200 households and 400 individuals composed by 200 men and 200 women.

Survey process and data analysis

We developed a survey questionnaire to collect information on household characteristics, and the types of forest and non-forest products that smallholder farmers collect for food and for building materials in a typical year, as well as those they collect following extreme weather events (such as cyclones or flooding). We also asked them to compare their current use of forest products (in a typical year and also following extreme weather events) to their use of these products 10 years ago. This allowed us to determine how the use of forest products has changed from 2001 to 2011.

In addition, we collected information on the local farmer's perception of how the climate had changed during the last decade, as well as their perception of the status and condition of forest resources (based on their estimation of the remaining stock, the availability of individual products, and the distance they had to travel from their village to collect particular products). The survey was conducted from November to December in 2011. The structured survey took between 30 to 45 minutes to deliver.

In addition to the household survey, we conducted one focal group discussion per village (a total of 10 focal groups) to double check the accuracy of responses and to obtain more background information. The objectives and the topics of the discussion were similar to the individual survey, however much of the discussion focused on understanding how their use of forest products has changed over the last 10 years their perception of climate risks, changes in the availability of forest products, crops, and crop lands (estimated area of cropland per

household), the importance of the forest products to cope with climate risks, and the relationship between the depletion of resources and the climate change during the last 10 years. One of the interviewers introduced the objectives of focal group and led the semi-structured discussion. Another interviewer took note from the discussion. Because the survey was coincided with the preparation of soil for cultivation (November to December) in which most of people are in the field, we invited all available people in the village to attend the focal group but the number of participants varied from 10 to 20 people, depending on the village.. In a few villages such as Ambinanisahavolo and Androfia, only few people composed by elder people, women and children could attend the focal group because most of them were working in the field. All focal groups were conducted in an outside space (e.g., under a tree) and took about 30 to 60 minutes to complete.

After the verification of the accuracy of datasheets, we recorded them into Excel file and used SPSS 17.0 for the data analysis (SPSS, 2008). We used univariate and bivariate analysis for the treatment of qualitative data. We used descriptive statistics to calculate the frequency of the use of forest products per municipality, the perception of resource depletion, and the coping strategies to solve the lack of croplands. In some tables or graphs, we combined data from the four municipalities or "communes" to illustrate the overall trends. To detect the change or trends of number of people that have used a given forest products from 10 years ago and today, we calculated the difference in the number of respondents that have harvested or hunted these non-timber forest products from 10 years ago and today.

2.3. Assessing the trends of the vegetation cover

To confirm the perception of depletion of forest products by the smallholder farmers within the target sites, we compared the map of vegetation cover from 2001 and that of 2011 to detect change of the type of land use cover. We used Conservation International's standard methods for conducting the spatial and temporal analysis of the vegetation cover and land use; then, we used (Conservation International, 2009; Andrieu and Mering, 2008). We conducted the analysis with four different scenes (with a size of about 180km x190km) of Landsat TM (Thematic Mapper) image (with 30 meters resolution) to characterize vegetation cover in 2000 and in 2010. The details of the analysis can be found in Appendix 1.

Acquisition and selection of satellite imageries

Satellite imageries Landsat TM were free downloaded from the NASA website and the South African National Space Agency (SANSA) (with 300usd/scène). To avoid the cloud cover we conducted the selection process was conducted to avoid the clouds cover.

3. Results

3.1. Household and livelihood characteristics

The main population in the western part of the corridor (Didy and Morarano) is composed by Sihanaka (40%) and t Bezanozano (38%) and in the eastern part of the corridor (Anjahamana and Beforona) is mainly composed by the Betsimisaraka (94%). Characteristics of the smallholder farmers' households within the target sites are described in Harvey et al. (2014). The education level of the chief of the households in these target villages was relatively low: 46% for primary school, 21% for secondary school and 30% of the respondents have never went to school. And the size of the household was relatively high with mean household size of 7.5 (±0.1) persons (Harvey et al. 2014).

The main livelihood activities for the farmers from the four target sites are agriculture (mostly for home consumption) and livestock production.

3.2. Use of forest products by smallholder farmers

In normal year, almost all respondents (97%) from the four target sites mentioned that they have used forests products for their livelihoods. In addition using firewood as the main fuel for cooking and using timber for building materials, each municipality has its own specific forest product needs. For example in Beforona and a few villages in Morarano such as Sakalava, they have used forest for Tavy or slash and burn for rice production and for selling timber. In Anjahamany, in addition to using forest products, they have practiced slash and burn for agriculture or Tavy. In Didy, respondents said that they need forest for harvesting timber for sale. During the focal group, they said that it is difficult to estimate the area of Tavy per household due to the various fallow lengths (from3 to 7 years) but it was about 0.5 to 1 ha per household. The following paragraphs describe the different use of forest products.

3.3.1. The use of woods and other building materials

Forests are currently used by the 85% of farmers from the four target sites for firewood and about 84% of them used forest materials (especially woods and leaves) for building houses in ten years ago and these percentages remain the same today. Only 47% of local farmers currently used forest products for handicrafts except in Beforona in which 60% of respondents mentioned that they used woods for crafts (Figure 2.2). Very few of them mentioned that they have collected timber for sale (12%). The other uses of forest products were are for medicine. Figure 2.2 shows that the number of respondents that have used forest for crafts and for sale reduced respectively from 55% to 21% and from 19% to 3% within the all sites.

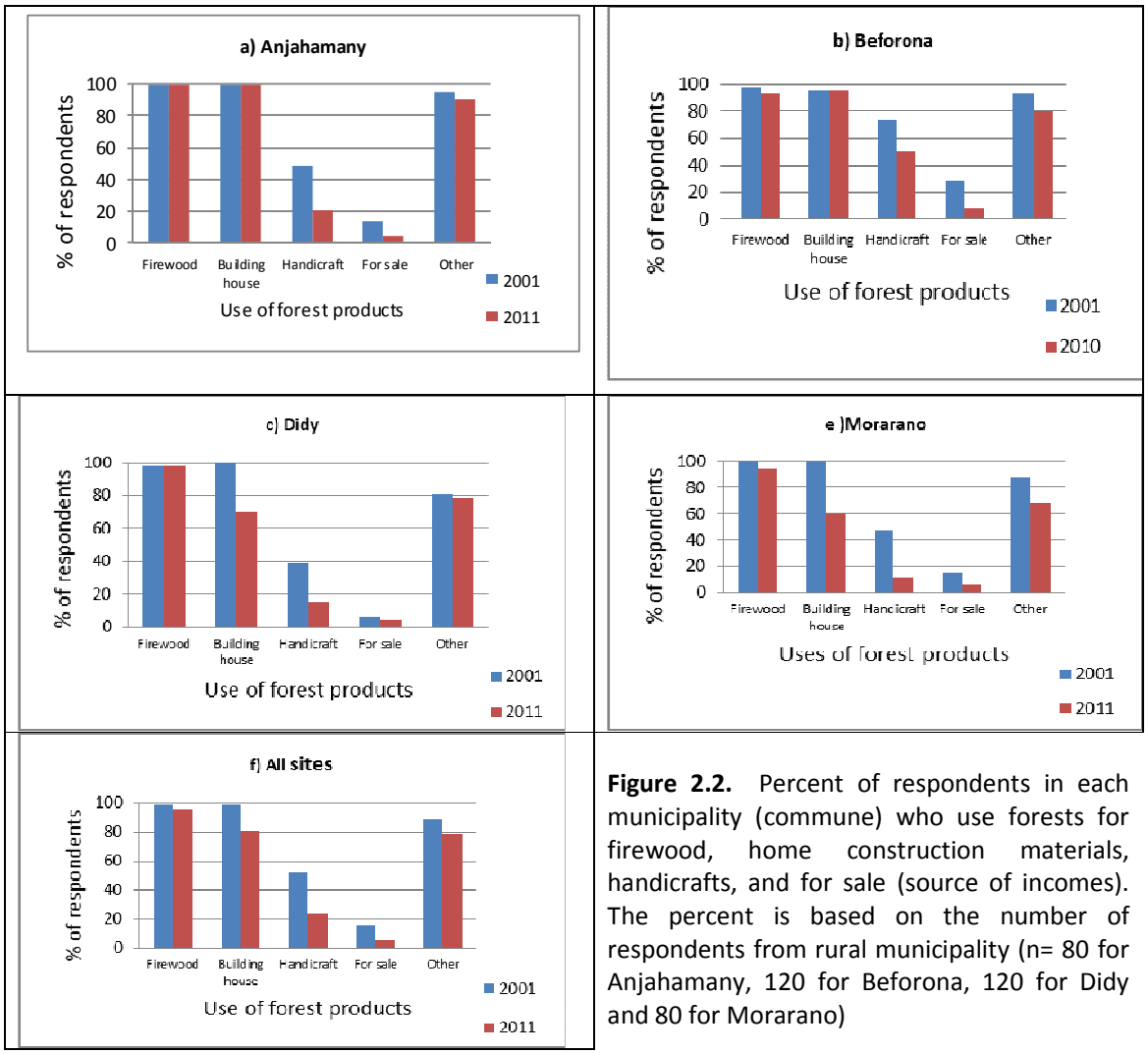

Figure 2.2. Percent of respondents in each municipality (commune) who use forests for firewood, home construction materials, handicrafts, and for sale (source of incomes). The percent is based on the number of respondents from rural municipality (n= 80 for Anjahamany, 120 for Beforona, 120 for Didy and 80 for Morarano)

Most smallholder farmers depend heavily on forest products as building materials or their homes, For example, 95% of respondents in Anjahamany and Beforona used forest products from Raphia (*Raphia ruffa*), bamboo (*Phyllostachys aurea*), Ravinala (*Ravinala madagascariensis*), and timber from other trees such as *Weinmannia lucens* (Lalona) and *Diospyros perrieri* (Maintipototra) in 2001 as materials for supporting the walls of their houses. (Figure 2.3). In Didy and Morarano, in contrast, respondents mentioned that almost all of their walls are made by non-forest products (bricks and mud) (cf. Photo 2.2). More than 50% of respondents from Anjahamany, Beforona, and Didy used forest products for building roofs (Ravinala and Cyperus sp). However in Morarano, only 43% of respondents used forest products for building roofs. Percentages of respondents are almost the same in ten years and today except for the use of timber as walls (Table 2.3).

Photo2.1: A village in Beforona with houses made by ravinala, © Randriarimalala Zo Lalaina

Photo2.2: Houses made by muds with cyperus for roofs and another house made by muds with tin sheets for roofs in, Sakalava village, © Randriarimalala Zo Lalaina

Photo 2.3: House mabe by wood in Beforona
© Randriarimalala Zo Lalaina

Photo 2.4: Farmers' houses in Anjahamany village
© Randriarimalala Zo Lalaina

Photos: Type of houses within the target sites

Most respondents mentioned that the availability of forest products for building walls and roofs has declined over the last 10 years. For example, during the focus group in Morarano, participants mentioned that 10 years ago (in 2001), they could harvest up to 52 pieces of timber. Similarly, in Anjahamany, ten years ago they could get up to 30 pieces of timber per harvesting trip of two week. However, in order to get the same amount of timber wood in 2011, a group of people composed by at least four persons have to walk for half day or more (about 20km or more) compared to only one or two hours (in 2001). Harvesting timber woods for house constructions requires permits from the rural community for forest management if their village has this kind of association. However, to get timber woods for sale (source of incomes), farmers must obtain permits the regional forest service.

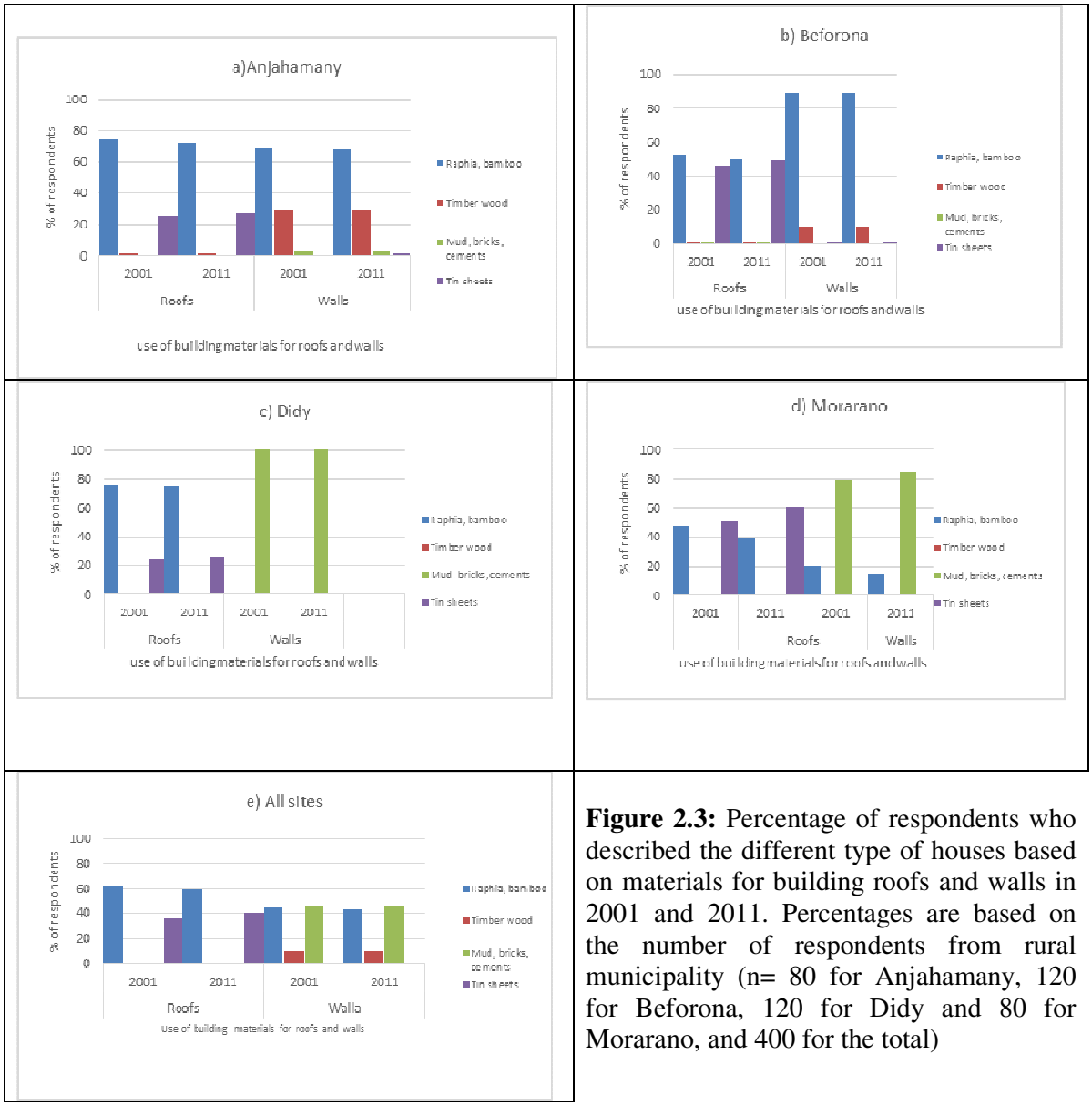

Figure 2.3: Percentage of respondents who described the different type of houses based on materials for building roofs and walls in 2001 and 2011. Percentages are based on the number of respondents from rural municipality (n= 80 for Anjahamany, 120 for Beforona, 120 for Didy and 80 for Morarano, and 400 for the total)

2.2.2. The use of non-timber forest products

Non-timber forest products (NTPFs) are defined as non-wood forest products which are useful to local people. In this study, they included edible plants such tubers and fruits, building materials, raw materials for crafts, and game animals.

Plants and honey

Ten years ago, up to 66% of respondents used non-timber forest products and honey except for the medicinal plants in which 66% of respondents collected them (Figure 2.4). Today the use of non-forest timber products is much lower. For example, whereas 73% of the population collected wild yams 10 years ago, today only 23% routinely collect wild yams. Similarly, reductions in non-forest timber products also occurred in honey (from 75% to 45%), and the raw materials for crafts (from 70% to 41%).

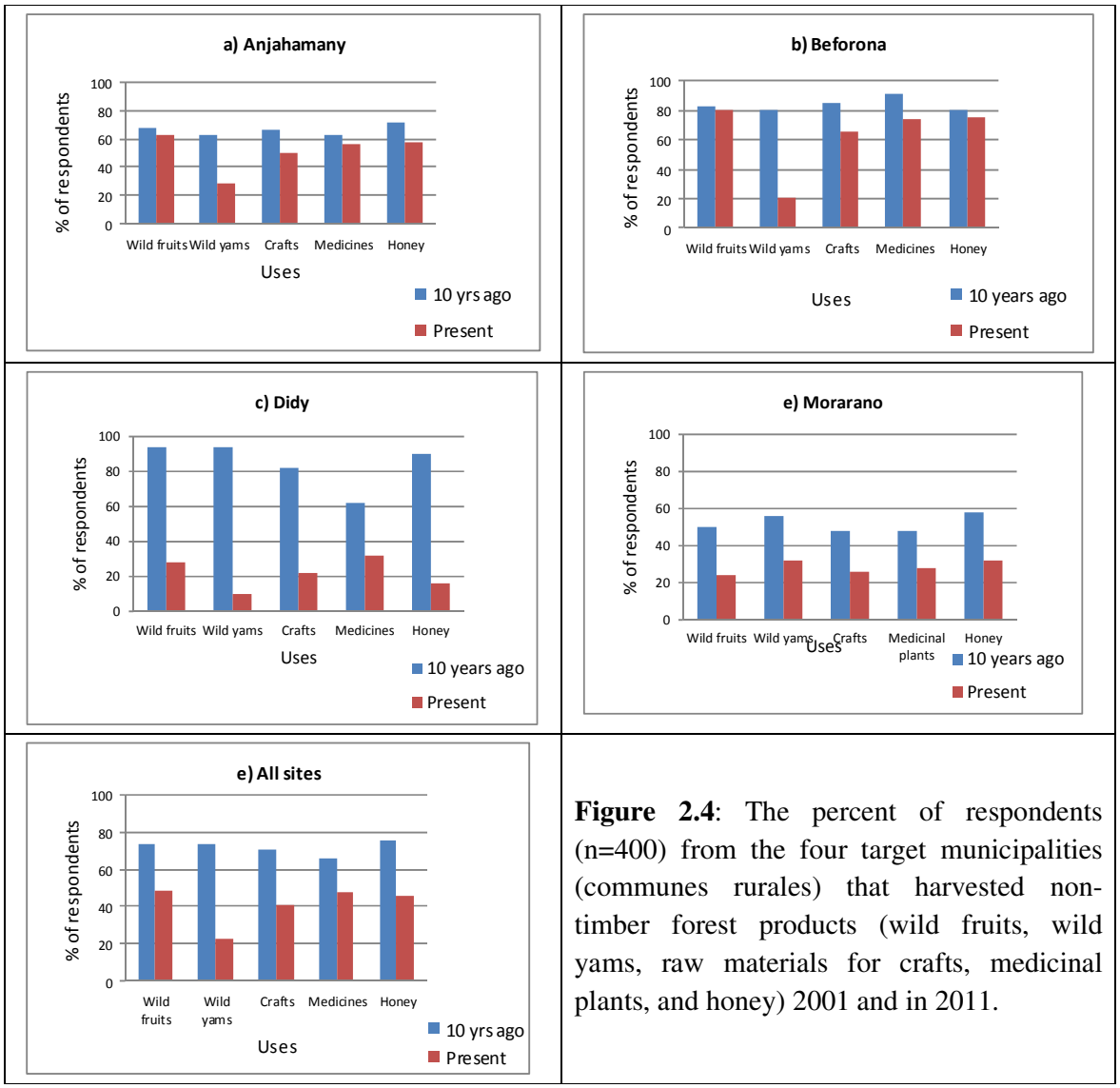

Figure 2.4: The percent of respondents (n=400) from the four target municipalities (communes rurales) that harvested non-timber forest products (wild fruits, wild yams, raw materials for crafts, medicinal plants, and honey) 2001 and in 2011.

The following paragraphs describe the focus group responses on the harvesting time per type of forest products and quantity of products that they collect currently.

Honey is harvested from November to May but the timing of harvesting varies across municipalities. In Anjahamany, farmers collected honey once a month from February to March, in Didy, it is collected from January to March, in Morarano from December to January and in Beforona from November to May. They can collect honey once or twice a month and can get only 3litres per collection in Didy or up to 30 liters in Anjahamany. Honey is mainly for sale, with once or twice a month; the price varying from 2000Ar (Anjahamany, Didy, and Morarano) to 3000Ar (in Beforona) per liter.

The harvesting of wild yams (Diosecorea sp.) is generally for household consumption according to 264 out of 400 respondents) but if they have to sell them, the price varies from 1000Ar to 2000Ar per kg. Farmers typically harvest wild yams from November to January and they can get up to 5kg per collect.

Harvesting time varies by the type of wild fruits, for example Jambolana (*Eugenia jambolana)* is harvested from February to April and china goyave (*Psidium cattleianum*), goyave is harvested from February to May. China, while Jambolana. For many of the other NTFP's, such as materials for handicrafts (mainly Cyperus sp. and palms) and medicinal plants, the harvesting time is more variable.

Bushmeats

In 2001, most respondents said that they hunted game animals. Across the four sites, in 2001 56% hunted bats, 78% hunted setifers, 80% hunted tenrec, 82% hunted birds and 85% hunted wild pigs (Figure 2.5). None of the respondents mentioned that they have hunted lemurs (either in 2001 or in 2011). However, 7 out of 120 respondents from Didy said that they have seen few traps for lemurs inside the forest.

The following paragraphs described the percent of hunting bushmeat per municipalities and per wild animal that are summarized in figure 2.5.

From 2001 to 2011, there has been a dramatic decline in the hunting of wild animals in all communities. For example, whereas 56% of the respondents said they hunted bats in 2001, none reported hunting them in 2011. Similarly, the number of people hunting birds has reduced from 82% to 19% over this ten year period, while the number of people hunting wild pigs has been reduced from 85 to 20. The hunting of setifers and tenrec has also declined over this time period, but to a lesser extent. The number of people who hunted bushmeat was high in Beforona and Didy compared to those of Anjahamany and Morarano.

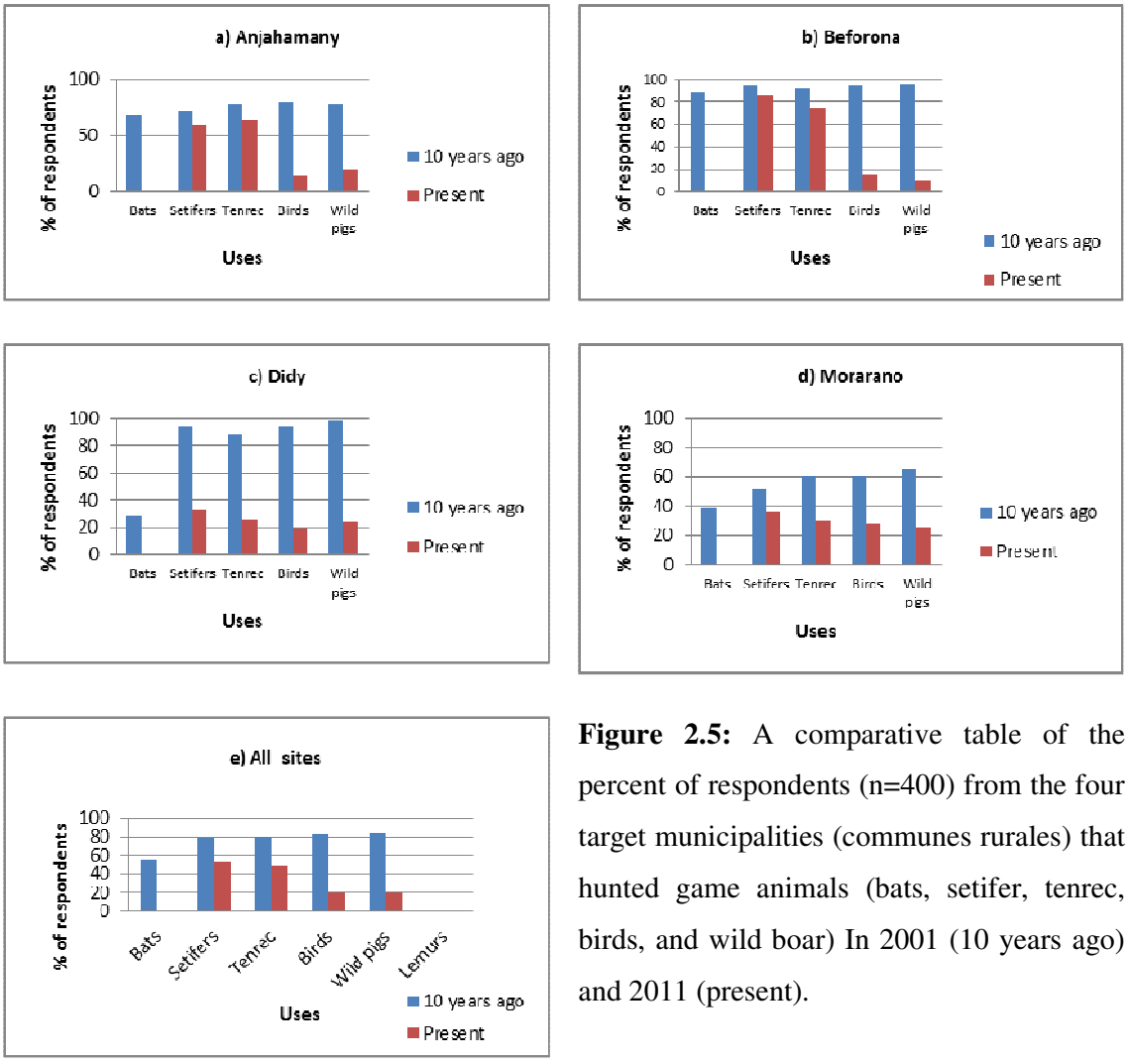

Figure 2.5: A comparative table of the percent of respondents (n=400) from the four target municipalities (communes rurales) that hunted game animals (bats, setifer, tenrec, birds, and wild boar) In 2001 (10 years ago) and 2011 (present).

As far as the Tenrec, 80% of respondents mentioned that they hunted *Tenrec ecaudatus* (Trandraka) before (10yrs ago) but nowadays 49% respondents mentioned that they have

hunted these species. In addition, they have hunted hedgehog such as *Setifer setosus* (Sokina)*, and Hemicenteles semispinos* (Sora)

In 10 years ago, about 85 respondents mentioned wild boar (*Potomochoerus ongules* or Lambo) from December to March and it was for consumption and for sale. Today, only 30% of them continue to hunt wild boar. The price of wild board meeting is about 3000Ar per kg. Wild board are hunted from December to January Anjahamany and from January to March in Didy and Morarano.

None of respondents mentioned that they have hunted bats today. However, about 76% of them said that they hunted bats in 10 years ago. As far as birds, about 77 out of 400 respondents have mentioned that they have hunted birds such as *Lophotibis cristata* (Lampirana), *Anas erythrorhyncha*, *Numida meleagris (*Akanga) today. However, in 10 years ago, about 82% of them hunted birds. None of the respondents have hunted reptiles and frogs in the past and today.

3.3. The perception of changes in the environment: climate, yields and livestock product, need of cropland, and forest products

Information on the perception of changes in climate, yields and livestock product, need of cropland, and forest products were collected to assess the link among these perceptions and the need of forest provisioning services.

3.3.1. Climate

In our study sites, 98% of the local farmer respondents have noticed the variation of climate over ten years period of time (80% in Anjahamana, 97% in Beforona, 100% in Didy, and 98% in Morarano; Figure 2.6). These changes included higher temperatures, changes in the first rains in the year, and a less and variable rainfall compared those during the normal year. In addition they mentioned that the humidity during the winter (May to August) has reduced. 60% of farmers from the eastern part of corridor (Anjahamany and Beforona) reported that cyclones have become intense. This change has noticed since the year 2000 and 2001 for the four target sites.

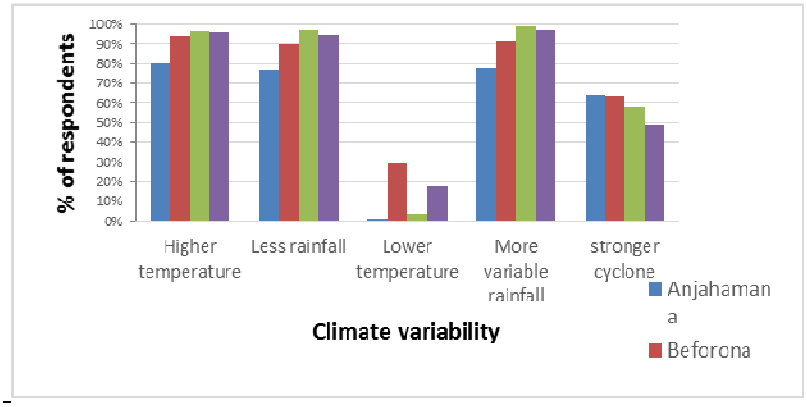

Figure 2.6: Percent of respondents from each municipality (n= 80 for Anjahamany, 120 for Beforona, 120 for Didy and 80 for Morarano) that have noticed change in climate: (increase of temperature, decrease and variability of rainfall, and severity of cyclone) in their rural municipalities since the year 2001.

3.3.2. Yields

Almost all farmers (99%) from the four target sites mentioned that their rice yields have decreased due to climate change. This reduction is due to the delay of the first rains and the variability of precipitation. During the focal group, they said that the soil became infertile because of they have to cultivate in the same crop land every year without using fertilizer. Reductions in crop yields have been reported since 2010 for Didy and Beforona and since 2003 for Morarano and Anjahamany.

3.3.3. The need of cropland

About 98% of respondents have mentioned that their actual cropland is not enough anymore to feed the household because of low production due to climate change. They mentioned about this climate change because they could not produce more yields due to the delay of the first rains, the variability of precipitation and the soil infertile. Then, their annual yields from their own crop lands could not feed anymore their household in one year. And 92% of respondents have mentioned that they must continue to grow crops because agriculture is their main livelihood activity. To solve the lack of crop lands, about 93% of respondents from Anjahamany, Beforona and Didy and 100% for Morarano said that they need more fertile soil and will obtain this by cutting the forest to establish new agricultural plots..

3.3.4. Ecosystem and Wildlife

Ninety percent of farmer respondents from the four target sites have noticed the reduction of forest near by their villages and increase of degraded forest and savanna. For example, respondents in focal groups mentioned that they now have to walk more than 20km to collect woods for rebuilding damaged houses after cyclone compared to only 5km in 10 years ago. Only less than 40% of farmers from Didy have mentioned the decrease of availability of wild food from the nearest forest.

3.3.5. Perception of the depletion of timber within the nearest forest

The majority of farmers mentioned that forests and their products are being depleted (Figure 2.6). Almost all farmers from the four target sites have noticed the depletion of timber woods from the nearest forest since 2000. About 86% of respondents have noticed the depletion of woods within the nearest forest (70% in Anjahamany, 89% in Beforona, 98% in Didy, and 88% in Morarano). About 64% of respondents mentioned that they now have to collected timber woods, at least more than 20km from their villages.

3.3.6. Perception of the depletion of non-timber forest products

Most of respondents from the four target sites have noticed the depletion of non-timber forest products (Fig.2.6), reporting that these products were either harder to find and/or less abundant. In Anjahamany, more than 90% of the respondents noted decreases in NFTPs.

The timing at which these products has become scarce varies both across different types of products and across different sites. For example, most respondents across all sites said that timber has become much scarcer since 2001. In contrast, honey has become scarcer in since 2006 in Anjahamanay and since 2010 in Didy and Morarano. We did not get the exact year of honey depletion in Beforona. Wild yam availability has been variable across years, but many respondents (252 out of 283 respondents) mentioned that yams were particularly scarce since 2007 for Anjahamany, 2009 for Befororna and Didy. For fruits, the majority of respondents mentioned that there are no enough fruits within the nearest forests (about two hours from their villages) (100% for Morarano, 93% of Anjahamany, 89% for Beforona, and 76% for Didy. Most farmer respondents have noticed the depletion of raw materials for crafts since 2007 in Anjahamany, 2006 for Beforona, and 2005 for Didy. We did not get the exact year when they perceived the depletion for Morarano.

For the medicinal plants, only farmers from Anjahamany and Didy have noticed that this depletion since 2006.

3.3.7. Bushmeats

Sixty one percent of respondents have noticed the scarcity of Tenrecidae within the forests near their villages. This depletion has been noticed since 2006 for Anjahamany and since 2001 for Didy and Morarano. Respondents from Beforona did not mention the exact year of this depletion.

About 59% of respondents have noticed that the availability of wild boar within the nearest forest has been reduced over the last 10 years (96% of respondents from Anjahamany, 73% for Beforona, 23% for Didy and 53% for Morarano). Respondents from Morarano have noticed this change since the year 2000. However, farmers from Anjahamany, Beforona and Didy were uncertain when this reduction in wild pigs began.

As far as the bats, about 60% of farmer respondents have noticed the depletion of bats (100% in Anjahamany, 66% in Beforona, 30% in Didy and 55% in Morarano). For the four target sites, this depletion was noticed since the year 2000.

About 63% of respondents reported that wild birds are scarce (100% for Anjahamany, 73% for Beforona, 30% for Didy, and 63% for Morarano. This change was noticed since 2001 and 2002 for Anjahamany and in the year 2000 for Didy and Morarano. Though respondents from Beforona have noticed this change, they did not remember the exact year of it.

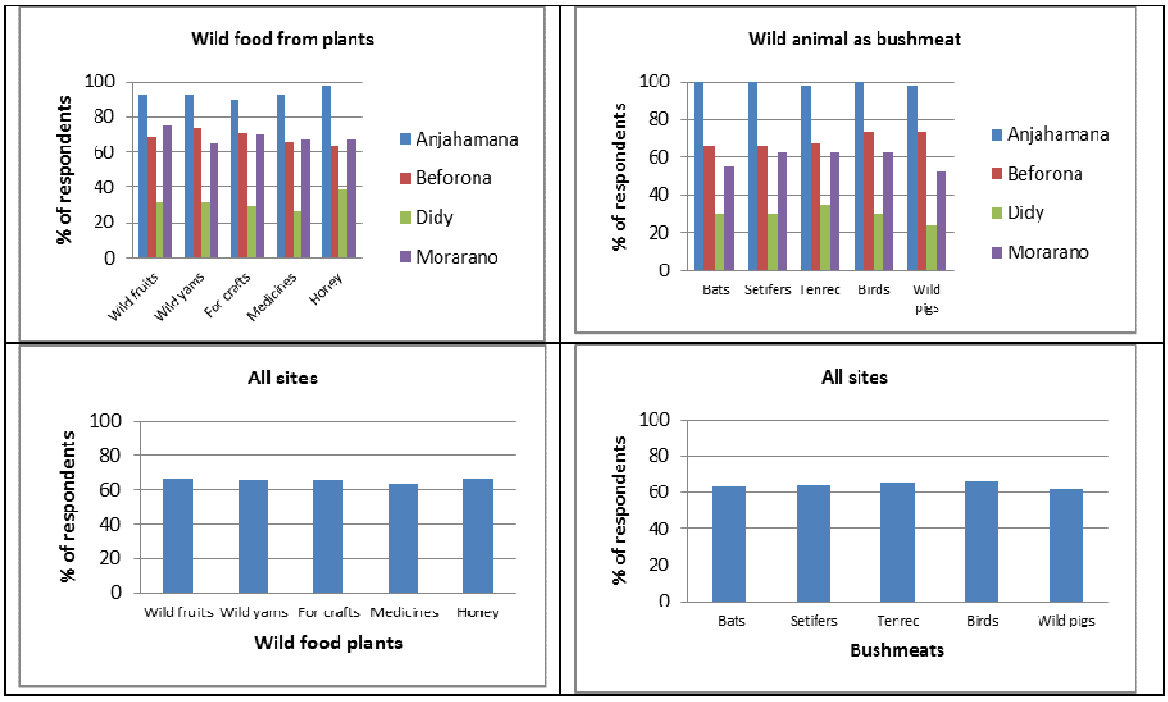

Figure 2.7: Percent of respondents from each municipality (n= 80 for Anjahamany, 120 for Beforona, 120 for Didy and 80 for Morarano) who have perceived a reduction in the availability of these forest products over the last ten years (from the year 2001 to 2011)

4. Discussion

4.1. Use of timber and non-timber forest products by the rural smallholder farmers

Our study shows that smallholder farmers depend heavily on forests both for their daily livehoods, as well as for coping with the impacts of extreme weather events, such as cyclones. At the same time, our study suggests that the availability of forest products and the ability of forests to help sustain rural livelihoods are declining due to deforestation and forest degradation, both of which reduce the availability of key forest products and services to farmers. Climate change will only further exacerbate the problem, as farmers will increasingly face reduced agricultural yields under climate change and be more affected by strong cyclones, making their need for forest products even more acute. Urgent action is needed to enhance the resiliency of smallholder farmer livelihoods, while sustaining the remaining forests and their services.

4.1.1. Timber forest products and building materials

One of the key uses of forests by smallholder farmers is as a source of materials for building homes. In our target sites, 84% of respondents mentioned that they have used forest products for building materials. During the focal group smallholder farmers mentioned that in regular years, local farmers have to renew the roofs or walls or the entire houses of their old houses made by ravinala or bamboo every five years in Anjahamany and Beforona. However for the houses made by mud or bricks and tin sheets, they do not have to renew them. However, if the houses are damaged by the strong rain or cyclone, they must collected timber and other forest building materials from the nearest forest to rebuild them the day after the weather events were ended. If their villages are located near by the forest, they can rebuild their houses in a short period of time with low cost (no or less transportation fees, collect local building materials). Therefore the existence of forests make these people more resilient to the or strong rain or cyclone. Smallholder farmers also depend on forests for firewood, which is the only source of energy for cooking for most villages. Some farmers from Morarano and Beforona make charcoal but it is mainly for sale to the major cities such as Moramanga and Antananarivo. As in other less developed countries (FAO, 2014), any people in the urban cities of Madagascar use charcoal due to lack of affordable source of energy (Aubert, 2003; MEEF, 2009; Gorenflo et al, 2011). A few respondents (12%) mentioned that they have logged forest to sell timber. Logging timber for sale may cost a lot for smallholder farmers because they need to have a logging permit and because timber trees are located far from their villages.

4.1.2. Wildfood Plants and Honey

Many smallholder farmers also depend on forests for food security. It is realized that in our target sites about 75% of household did not get enough rice year-round (Harvet et al., 2014) and the lean season coincide with the harvesting time of wild food (November to May).The most commonly used wild foods collected in forests were honey, wild yams, and wild fruits. These forests products are crucial for farmers to cope with food shortages and also as additional source of incomes. Harvesting wild food does not have impact on the size of forests if they are for household consumption not for urban trade (Aubert, 2003).

About 40% of respondents mentioned that they collect honey from September to May, depending on the region. All of them have used the traditional way for collecting honey consists of cutting down tree that served as hives to get the honey. Honey is mainly for food

(sugar) and medicines for coughs, unless they have access to market so they can sell it. Many people appreciate honey from forests and it is an additional source of income if smallholder farmers can bring them to the market (Aubert, 2003; Raoelinarivo, 2014). In the rural areas, the price was about 3000Ar the liter but in the markets in the big cities it varies from 5000Ar to 7000Ar per liter. One farmer can get from 10 to 30 liter per time of collect.

Respondents from the target sites mentioned that they have harvested wild yams from forests (*Dioscorea alata, Dioscorea bulbifera, and Dioscorea ovinala).* Some findings show that wild yams serve as significant and most common substitution of staple foods during the food shortage for the rural people in Madagascar (Wilkin, 2007; Harvey, 2014).

For fruits such as goyave, wild orange, java plums (*Eugenia jambolana*), and which ones that most of farmers have collected for consumption , except for farmers who live near by the main road (from Toamasina to Antananarivo) where they can sell wild fruits such as China guava (1000Ar/ bucket of 10 liters). Some fruits such as *Eugenia jambolana* and citrus are eaten by the farmers as food and as medicines (Ratsimamanga, 2002; Kent, 2013).

Raw materials for crafts are useful for the households (mats, baskets, hats) but are not an important source of income due to the lack of access to markets. Key materials include *Pandanus utilis* (Vakoa) for mats and big baskets, *Cyperus latifolius* (vendrana) for roofs, mats, and baskets and *Cyperus madagascariensis* (zozoro) for roofs, mats, doors and windows.

In Madagascar, it is estimated that 2300 plant species are medicinal from primary or secondary forests (MEEF, 2009) and more than 60% of Malagasy use them (MEEF, 2014). In the normal year, as the Hospital is located in the town, a little far from their villages (15km without public transportation), smallholder farmers use leaves or barks of medicinal plants to heal common diseases such as flu, diarrhea, and fever. There is often widespread of common diseases following cyclones and because smallholder farmers cannot access emergency support (Harvey, 2014) due to the distance of their villages from the Center of emergency support, they use medicinal plants to treat most illness except for severe injuries. In addition to the use of medicinal plants for their own health, farmers sell some medicinal plants such as *Cinchona siccirubra*, *Canarium, Ravensara*, and *Pygeum africana* to earn money (Andriatsiferana and Ramiarison, 1993, FAO, 2003, MEEF, 2009).

4.1.3. Bushmeats

Respondents mentioned that they have hunted wild animals for meat such as wild boar, hedgehog (tenrec), and birds. In rural areas, game animals serve as an additional source of animal protein (MEEF, 2009; Jenkins et al., 2011), as well as a source of additional income (Andrianjakarivelo, 2003, Jenkins, 2008). During the survey, in cases of emergency, smallholder farmers have sold their livestock to earn additional income (Harvey et al, 2014). Traditionally, Malagasy farmers have eaten livestock for the family special events or when they will have visitors (Rakotondravony, 2006). This traditional way of keeping livestock may lead to the lack of animal protein supply in rural areas and increase the need of bush meat (Andrianjaka, 2003). Though local people eat bushmeat, they prefer eat domestic animals such as pig and zebu (Jenkins et al, 2008). Bushmeat is therefore both an important as source of additional incomes and makes an important contribution to local protein supply.

The degree of hunting varies across different wild animals. For example, more than 50% of respondents hunted Tenrec. It is widely hunted in many regions of Madagascar because people like its taste (Nicoll, 2003; Jenkins et *al.,* 2011) but some of them are enable to eat tenrec because of taboo. Smallholder farmers hunt bushpig not only for animal protein supply but also to protect their crop against the destruction made by the bush pig. In some areas of Madagascar, it is an additional source of income (Andrianjakarivelo, 2003). None of respondents mentioned that they have hunted bats in 2011 but some of them hunted bats in 10 years ago. Jenkins (2007) found that rural people have hunted bats year-round in Madagascar. In the western part of Madagascar, bats are available local restaurants. None of respondents said that they hunted lemurs because they are protected. Jenkins et *al.,* (2011).said that it may due to the fact that hunting lemurs is taboo for rural people.All respondents mentioned that they did not hunt frogs. However, Jenkins (2008) found that rural farmers in Alaotra Mangoro region have hunted Mantidactylus sp. for meat (legs of frogs) to sell in markets and restaurants in Antananarivo to earn extra income. In addition, international pet trade of amphibian species (Mantella sp) from the rainforest near be the target sites trade is high with significant source of income through legal sale (Rabemanjara et *al.,* 2008; Jenkins et al., 2008). As far as birds, more than 75% of respondents have mentioned that they have hunted birds such as *Lophotibis cristata* (Lampirana), *Anas erythrorhyncha*, and *Numida meleagris* (Akanga). People have hunted them by using traps made by rope of liana and blowpipe (Aubert 2003; Jenkins, 2008). None of respondents have mentioned that they hunted reptiles.

Wild animals are both for daily food supplies, as well as for dealing with the lean season. Most wild animals are harvested from November to May, which coincides with the lean season, from November to March (Harvey et al, 2014) and with the cyclone season, November to May (Tadross et al, 2008).

Change in use and availability of forest products

Though it is realized that percent of respondents that have used forests products in ten year ago was high compared that of today (Figure 2.2 and 2.4), it is noticed that there is a strong need of these provisioning services by the smallholder farmers due to current various agricultural risks. For example, the increase in the duration of lean season has augmented the need of wild foods (Harvey et al, 2014).

Our study clearly shows that the collection of wild foods has decreased over the last ten years (2001 to 2011).Most respondents indicated that they are harvesting fewer wild food because deforestation has made them less available. Other studies have similarly found that wild food availability as decreased due to deforestation and bushfire (Clayton, 2011; Styger, 2007). Deforestation is high in the study regions, with an annual rate of 0.7% in Alaotra Mangoro region (Didy, Beforona, and Morarano) and the 0.2% r in Antsinanana region (Anjahamana) from 2005 to 2010 (ONE et al., 2013).

4.1.4. Perception of change on climate

Most of smallholder farmers within the target sites have noticed changes in the climate over the last 10 years. These changes included an increase of temperature, decrease of humidity during the winter (May to August), and irregular rainfall. These climate changes have important ramifications for their livelihoods. For example, the variation of temperature may impact the health of their livestock and the spread of crop diseases and pests.

The change in rainfall is particularly evident to farmers. Their traditional agricultural calendar is based on the first rains of the year arriving in November. Now, the first rains are more variable and may only arrive in late December (is this what you mean?) During the focal groups, farmers mentioned that they have adjusted their agriculture calendar by waiting this first rain of the years but sometimes it was followed by a period of no rain (one month).In addition, the crop productivity depends on the quantity of rainfall. In Beforona and

Anjahamany, smallholder farmers have noticed that the cyclones have become more intense since 2000-2001. Farmer perceptions on changes in climate coincide with the scientific findings on climate variability, increase of temperature and irregularity of rainfall (Tadross et *al.,* 2008). For example, rural people in the eastern part (Analanjirofo region) of Madagascar have similarly reported an increase of intensity of cyclone since 1986 (Raharinjanahary, 2010).

4.1.5. Perception of decrease of yields

The decrease of crop productivity is one of the most common impacts of climate variability in the rural areas according to the focal group discussions. Ninety eight of the farmer respondents have noticed the decrease of yields due to the lack of soil fertility and the variability of precipitation since the year 2000. As their main livelihood activity is agriculture, they must continue growing crops and need more fertile cropland from the practice of slash and burn for agriculture.

4.2. The need of cropland and change of vegetation cover

Our result shows that 98% of respondents have perceived the lack of cropland due to climate variability. Farmers report that climate change has reduced crop productivity due to decrease of soil fertility, lack of water (delay of the first rain in the year or the variability of precipitation), the widespread disease of crops due to the the increase of temperature. Faced with these risks related to climate change, they could not afford fertilized and medicines for crops and their crops production from their own cropland could not feed anymore their family. This decrease of yield was noticed by the Malagasy farmers since 1999 (MEEF, 2007). The other reasons for the growing need for cropland is a) the increase in the size of households without increase of cropland and b) the lack of other livelihood options available for uneducated farmers. About 70% of respondents from Morarano, Didy and 41% for Anjahamany and Beforona have only the primary level of education (Harvey et al 2014). Many farmers prefer to stay in their village and cultivate existing cropland (shared among the family members) rather than finding another job to the cities because of the low education level (Aubert, 2003). As they mentioned during the survey, though they suffered the lack of cropland, almost none of them intend to buy cropland. It may due to the lack of funds or the

tradition of cultivating on "domanial" land (State lands). In addition, most of their cropland is inherited from their ancestors (Aubert, 2003). The population growth rate in Madagascar is high (3.3%), so as the size of family increases, the amount of cropland per capita decreases and the yields are insufficient to meet household demand. This situation is exacerbated by the impacts of climate variability on crop productivity. This is why 98% of respondents mentioned that to cope with climate risks; they need to practice more Tavy to feed their family. Tavy, in turn, is the main driver of forest loss (Marcus, 2001; Styger, 2009, Gorenflo et al, 2011).

4.3. Perception of the depletion of the timber and non-timber forest products

About 80% of smallholder respondents have noticed the depletion of timber and non-timber forest products from 2001 to 2011. According to farmers, the depletion of wild foods is due unsustainable use or extraction by people.

Our results show that few people harvest wild foods and hunt game animals today compared to the time in 10 years ago. Whereas 10 years ago more than 75 % of the population harvested wild foods from forests, today only about 57% do. Similarly, whereas 10 years ago, more than 80% of the population hunted game animals, today only 55 % do. The decline in the collection of wild foods was due increased scarcity of wild foods within the nearest forest or the fact that families live further away from forested areas. According to them, they did not want to spend almost half day walking without getting any wild food. The reduction in hunting may be partly due to the fact that hunting of game animals is illegal (Jenkins, 2007) and there have been many awareness campaigns about the need to protect forest and wildlife. The decline in non-forest timber product use is variables across communities (Figure 2.7), with Didy having experienced the greatest overall reduction in collection of these products.

This perception of scarcity of forest products due to the deforestation was proved in our forest cover analysis from the year 2000 to 2010 (Table 2.2). It shows that there is a reduction of the eastern humid forest from 537,121.53ha to 518,181.21ha and increase of degrade humid forest from 420,092.73 ha to 439,033.05ha (cf. table 2.2). It may due to conversion of forest into agricultural lands.

Table 2.2. Trends of vegetation cover within the corridor Ankeniheny Zahamena from 2000 to 2010 within the corridor Ankeniheny Zahamena

Vegetation	**Area 2000 (ha)**	**Area 2010 (ha)**
Water	2,515.23	2,515.23
Bare soils	151.92	151.92
Cultivated areas	130,438.80	130,438.80
wooded grassland/bushland mosaic	106,896.87	106,896.87
Grassland/wooded grassland mosaic	194,661.90	194,661.90
Eastern humid forest	537,121.53	518,181.21
Degraded humid forest	420,092.73	439,033.05

NB: The land use described here are described in the Madagascar vegetation atlas (Moat and Smith, 2007)

The depletion of these forests size and their products have impact on the viability of the use of forest products to cope with climate change. And the uses of forest products can lead to its depletion. Finding solutions to use forest products without harming them is the huge challenge for Madagascar

4.4. Recommendations

There is an urgent need to ensure the conservation of the remaining forest areas, so that these areas can continue to provide the goods and services on which local people depend. Introducing the rural development program into the forest conservation planning would be helpful by involving all stakeholders for its implementation. Activities such as community forest management and conservation agriculture have been implemented successfully in Madagascar (FAO/TFNAC, 2015) but they need to be scaled up. Community forest management would be useful to help people in using forest products sustainably as well as managing natural resources. Any type of rural development activities that reduce

deforestation should be implemented. For example the conservation agriculture, soil conservation, cover cropping, and agroforestry (Dupin, 2011; FAO/TFNAC, 2015), such activities would be helpful to improve soil fertility and to avoid the extension of croplands into the forest areas.

Policy makers should acknowledge the close links between natural ecosystems and farmer livelihoods and the important role of natural ecosystems as safety nets for farmers following natural disasters, and ensure that adaptation, agricultural, poverty alleviation and rural development strategies explicitly promote the conservation and sustainable management of natural ecosystems within agricultural landscapes. During the focus group, we realized that most of them have mentioned the urgent action in tree plantation because of its critical services into their livelihoods. Then, in areas in which natural ecosystems have been degraded by unsustainable use, policies and strategies should also encourage the restoration of degraded areas through reforestation or natural regeneration, to ensure that smallholder farmers will continue to be able to access wild foods, timber, thatch and other key products in the years to come without destroying the primary forests.

5. **Conclusion**

In Madagascar, smallholder farmers depend strongly on forest ecosystems for their livelihoods, both in regular years, as well as in years of extreme weather events. Forests are particularly important for helping people cope with the impacts of significant climate risks, such as cyclones. However, while these coping strategies adopted by the smallholder farmers may effective in the short term, in the long term, their dependence on forests for food and building materials may lead to habitat destruction and deforestation, thereby undermining the forest ecosystem on which they depend. The big challenge for Madagascar is to find strategies to ensure the conservation, restoration and sustainable management of forests so that these forests can continue to provide key services to rural communities over the long term, without undermining the health of these forest ecosystems. If the smallholder farmers depend on forests for their livelihoods, appropriate community forest management strategies should be implemented to avoid the depletion of forest products. Activities such as technical training in terms of sustainable use forest, forest patrol and forest restoration need to be enhanced. As these smallholder farmers are very poor, their agriculture productivity should

be increased through the improving of agricultural inputs and technical support and revitalizing local agricultural infrastructure. This would both reduce the need for farmers to clear additional land for tavy, and also enhance their food security; thereby reduce their dependence on forests for wild food and bushmeat.

Part three:

Smallholder farmers, cyclones and coping strategies: a case study from Zahamena Ankeniheny Corridor and Nosivolo, Madagascar

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Résumé

Dans de nombreux pays tropicaux, les petits exploitants agricoles sont très vulnérables aux cyclones et eprouvent des pertes de récoltes importantes, l'insécurité alimentaire et la perte de revenus lorsque les cyclones ont frappé. Madagascar a un des taux les plus élevés de cyclones à l'échelle mondiale et une population composée principalement de petits exploitants agricoles mais il y a peu d'informations sur la façon dont les petits exploitants agricoles malgaches se préparer et à faire face à l'cyclones. Nous avons mené des entrevues avec 200 petits exploitants agricoles malgaches suite aux impacts du cyclone Giovanna (un cyclone de catégorie 4 qui a frappé en Fevrier 2012) pour comprendre comment les agriculteurs préparés pour le cyclone, comment le cyclone affecté leurs moyens de subsistence et quelles stratégies les agriculteurs utilisés pour faire face à ces impacts. La plupart des agriculteurs avaient préparé pour le cyclone en stockant l'eau propre; certains avaient également fixé leurs bâtiments et stockés des nourritures et des semences.Cyclone Giovanna avait causé des dommages importants sur les cultures, les produits agricoles stockes et les maisons, et la sécurité alimentaire des agriculteurs considérablement réduit. . Les agriculteurs ont fait face au cyclone en faisant une replantation des champs de culture, une reconstruction des maisons avec des matériaux locaux, ce qui réduit la consommation d'aliments de base, la récolte d'aliments sauvages et à trouver du travail temporaire pour acheter de la nourriture. Les réseaux sociaux informels ont été essentiels pour fournir la nourriture et reconstruction houses.There est un besoin urgent pour les gouvernements, les donateurs et les organisations de développement pour réduire la vulnérabilité des petits agriculteurs malgaches à cyclones par l'amélioration des systèmes d'alerte précoce, l'augmentation de la préparation aux agriculteurs pour les cyclones, la création filets de sécurité formels pour aider l'accès des agriculteurs nourriture et des fournitures essentielles suivantes cyclones, et la promotion de l'utilisation des mesures d'adaptation pour renforcer la résilience des petits exploitants agricoles aux futurs chocs climatiques.

Mots clés : Stratégies d'adaptation, Cyclones, Sécurité alimentaire, Madagascar, Petits exploitants agricoles, Vulnérabilité

Summary

In many tropical countries, smallholder farmers are highly vulnerable to cyclones and experience significant crop losses, food insecurity and income loss when cyclones hit. Madagascar has one of the highest rates of cyclones globally and a population comprised primarily of smallholder farmers, yet there is little information on how Malagasy smallholder farmers prepare for and cope with the cyclones.We conducted interviews with 200 Malagasy smallholder farmers following the impacts of cyclone Giovanna (a category 4 cyclone that struck in February2012) to understand how farmers prepared for the cyclone, how the cyclone impacted their livelihoods and what strategies farmers used to deal with these impacts. Most farmers prepared for the cyclone by storing clean water; some also secured their buildings and stored food and seeds. Cyclone Giovanna caused substantial damage to crops, stored grains and houses, and significantly reduced farmer food security. Farmers coped with the cyclone by replanting crop fields, rebuilding homes with local materials, reducing consumption of staple foods, harvesting wild foods and finding temporary work to buy food. Informal social networks were critical for providing food and re-building houses.There is an urgent need for governments, donors, and development organizations to reduce the vulnerability of Malagasy smallholder farmers to cyclones by improving early warning systems, increasing farmer preparedness for cyclones, creating formal safety nets to help farmers access food and essential supplies following cyclones, and promoting the use of adaptation measures to enhance the resiliency of smallholder farmers to future climate shocks.

Key words: Coping strategies, Cyclones, Food security, Madagascar, Smallholder farmers, Vulnerability

1. Introduction

Tropical cyclones are known to have significant global impacts on human health, livelihoods and economic activity. It is estimated that 35% of the world's population is affected by cyclones (Hsiang and Jina 2014) and that cyclones affected 466 million people from 1980 to 2009 (Doocy et al., 2013). In addition to the immediate impacts on human health, livelihoods

and local economies, severe cyclones often set back a country's development by several decades (Hsiang and Jina 2014), as seen in Honduras after the impacts of hurricane Mitch (Abramovitz, 2001).

Madagascar is one of the tropical countries that is most affected by cyclones globally and has one of the highest rates of cyclones in Africa (The World Bank, 2010; Clayton, 2012; Doocy et al., 2013). Each year an average of 3 to 4 tropical cyclones originate in the Indian Ocean and the Mozambique Channel and hit Madagascar during the cyclone season from November to April (Ganzhorn, 1995; Mavume, 2009; The World Bank, 2010; WFP, 2011). The high winds, excessive rainfall and associated flooding from cyclones have devastating impacts on both the national economy and local livelihoods (Harvey et al., 2014; Hsian and Jina, 2014; Nash et al., 2015). Cyclones damage infrastructure, flood agricultural areas, destroy crops, injure cattle, threaten food security, contaminate water supplies, increase the incidence of water-borne diseases, and cause human injuries and sometimes deaths (Shultz et al., 2005; Clayton, 2012). The associated economic and humanitarian costs of natural disasters in Madagascar are enormous: it is estimated that floods, drought and cyclones have affected more than 11 million people in Madagascar in the last 35 years and resulted in roughly 1 billion US dollars of damage (The World Bank, 2010; UNHRC, 2011). Across Madagascar, about five million people (or ~25 % of the entire population) are estimated to be vulnerable to natural disasters such as cyclones, droughts and flooding (The World Bank, 2015). The frequent occurrence of cyclones is also a major contributor to the country's extremely high levels of poverty and food insecurity (Clayton, 2012; The World Bank, 2015). Climate models project that Madagascar is likely to have fewer but more intense cyclones in the future due to climate change (Tadross et al., 2008, Mavume, 2009), which means that finding ways to reduce the vulnerability of the Malagasy population to these cyclones will become even more critical in the near future.

While cyclones affect all sectors of society, the most vulnerable communities are usually those that are poor, marginalized, and without access to formal safety nets (Dercon, 2002; Hertel and Rosch, 2010; Mutabazi, 2015; Bhatta and Aggarwal, 2016). Studies from other countries that are regularly affected by cyclones, such as Bangladesh (e.g., Alam and Collins, 2010; Uddin et al., 2014), India (Bahinipati 2015; Bahinpati and Venkatachlam 2015), Mozambique (Osbahr et al., 2008) and Indonesia (Candradijaya et al., 2014), among others, have highlighted that smallholder farmers are particularly vulnerable to cyclones. Smallholder farmers (generally defined as those having less than 2 ha of land, (The World

Bank, 2003) are vulnerable to climate shocks due to their dependence on rain-fed agriculture, limited areas of arable land, high poverty levels, food insecurity, lack of access to information and limited resources to prepare for and cope with the impacts of cyclones (e.g., Morton, 2007; Mutabazi et al., 2015, Bhatta and Aggarwal, 2016). The coping strategies of smallholder farmers to climate shocks and longer term adaptation plans are often place-specific and adapted to local circumstances (Brockhaus et al., 2013). Consequently, detailed information on how smallholder farmers in particular landscapes are already responding to climate shocks is needed to inform the development of strategies and policies to their vulnerability to climate shocks and to enhance their adaptive capacity (Bahinipati and Venkatachalam, 2015).

In Madagascar, smallholder farmers are known to be at great risk from cyclones (Harvey et al., 2014), but to date there have been no studies on the specific impacts they experience and how they cope with these impacts. An estimated 71% of Malagasy farmers are smallholders (Ministry of Agriculture, 2009. INSTAT, 2011), with a national average upland rice area per farmer of only 1.28 ha (Zeller et al., 1999). Most Malagasy smallholder farmers practice subsistence farming, depending on agriculture both for food security and for household income, and are seasonally food insecure (Randrianarisoa and Minten, 2001; Dostie et al., 2002; Barrett et al., 2004; Doocy, 2013; Harvey et al., 2014). Most smallholder farmers are also extremely poor, with an estimated 87.4% of smallholder farmers falling below the national poverty line (INSTAT, 2011). As a consequence, Malagasy smallholder farmers are therefore extremely vulnerable to extreme weather events that reduce agricultural productivity or cause crop loss.

The overall objective of our study was to understand how Malagasy smallholder farmers prepare for and cope with the impacts of cyclones, using a case study of how smallholder farmers reacted to cyclone Giovanna that hit Madagascar in February 2012. Cyclone Giovanna was a category '4' cyclone (on the Saffir-Simpson Hurricane Intensity Scale of 1 to 5, where 1 is the weakest and 5 the strongest; (Meteo France, 2008)), with winds of up to 269 km per hour and a total of 355.6 mm of rainfall occurring over three days (Gutro, 2012). The cyclone is known to have affected at least 246,000 people, destroyed >44,000 houses, damaged >27,000 houses and damaged at least 12,517 ha of agricultural land across Madagascar (BNGRC 2012), but the real impact was likely greater given that information on impacts was only reported by 250 of the 697 municipalities in Madagascar (BNGRC, 2012). We conducted surveys of 200 farmers to: a) explore how farmers prepared for cyclone

Giovanna and how effective their preparations were in reducing vulnerability; b) document the specific impacts of the Giovanna cyclone on agricultural production and farmer livelihoods (including impacts on income, health, housing and food security); and c) examine how farmers coped with the impacts of cyclones on their farming systems and livelihoods and how effective these coping strategies were in reducing their vulnerability.

While there are existing government assessments of the overall impacts of individual cyclones (including cyclone Giovanna) at the district, regional and national levels (Government of Madagascar, 2008; BNGRC, 2012), to our knowledge, this is the first study in Madagascar to collect detailed household-level data on the specific impacts of cyclones on smallholder farmers and to examine the coping strategies used by farmers to deal with these impacts. Our study provides unique insights into how smallholder Malagasy farmers are affected by cyclones and highlights key measures which could be incorporated into Madagascar's National Action Program for Adaptation to Climate Change for Agriculture (PANA), the National Strategy for Risk Management (SNDRM; UNDP/CNS, 2010), National Action Plan for Food Security (PANSA), and the Poverty Reduction Strategy Paper (DSRP) among other national strategies. Our results also provide valuable information for donors and development agencies interested in improving food security, alleviating poverty, and reducing the overall vulnerability of Malagasy smallholder farmers to climate change. In addition, our study illustrates the complexity of addressing smallholder farmer vulnerability to extreme weather events, an issue which is relevant to other cyclone-prone developing countries (e.g., Candradijaya et al., 2014; Bahinipati, 2015; Mutabazi et al., 2015)014).

2. **Materials and methods**

We examined how smallholder farmers prepared for and responded to cyclones in two agricultural landscapes located along the eastern escarpment of Madagascar -the Ankeniheny Zahamena Corridor (CAZ) and Nosivolo, both of which were significantly impacted by cyclone Giovanna (Figure 1). The CAZ landscape is located adjacent to the Ankeniheny Zahamena forest, one of the largest remaining rainforests in Madagascar, while Nosivolo is a riverine protected area located further south in the District of Marolambo. Both landscapes are characterized by a mix of agricultural land, regenerating forests (from slash and burn) and remnant forests, and are inhabited by smallholder farmers who typically cultivate less than 2

ha of land (Harvey et al., 2014; Table 1). The traditional and most common agricultural practice in both sites is the use of slash and burn ('tavy') for rice production for home consumption (Styger et al., 2009; Ratsimbazafy et al., 2011). Other crops grown in tavy areas include cassava and corn. In the lowland areas of each site, farmers also grow irrigated rice and cash crops. Some farmers also raise poultry on a small scale or produce charcoal for sale to urban areas. Most farmers in the region live below the national poverty line, are food insecure for several months per year (Harvey et al., 2014) and have large families. Their houses are constructed of local materials such as timber, mud bricks and the bark or leaves of Ravinala madagascariensis and Raphia ruffa (Harvey et al., 2014). Both areas are remote and have poor road infrastructure. Roads in Nosivolo are only accessible during the dry season. In CAZ, only the southern and western parts of the landscape are accessible by road year-round.

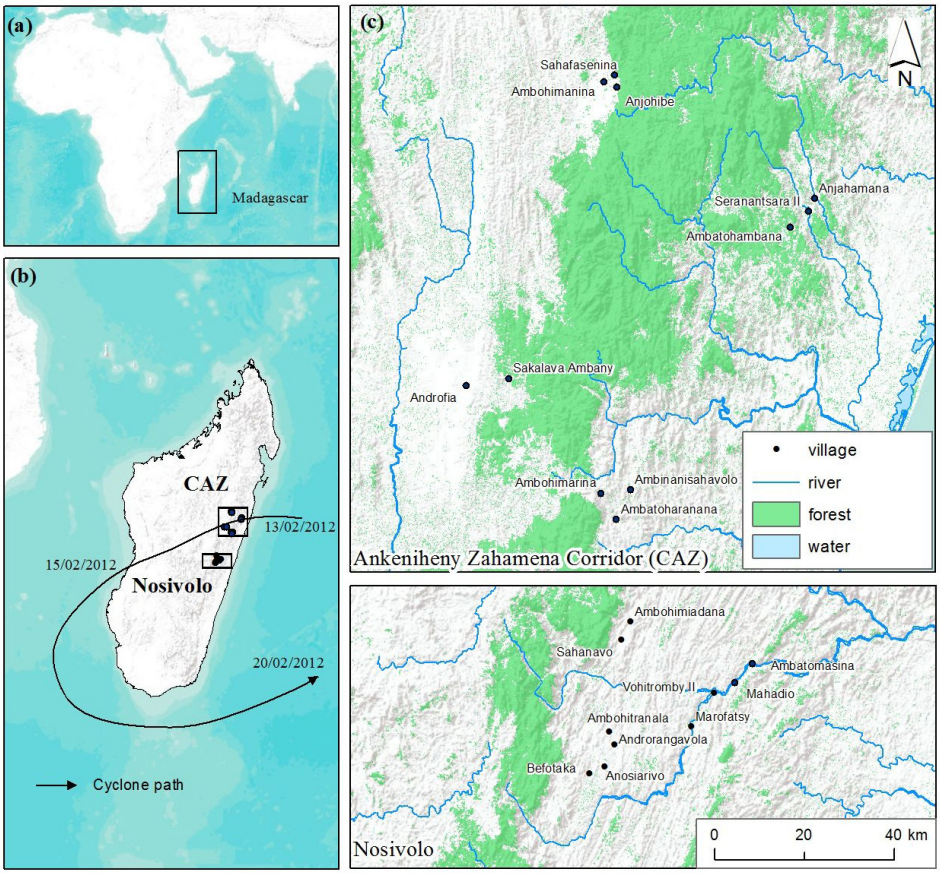

Figure1. A map showing a) the location of Madagascar; b) the pathway of the Giovanna cyclone across Madagascar in February 2012 (with date and time of landfall indicated), and c) the location of the villages in the two study landscapes (CAZ and Nosivolo) where the impacts of cyclone Giovanna on smallholder farmers were examined.

Table 1. Biophysical and social characteristics of the landscapes where the impacts of cyclone Giovanna on smallholder farmers were explored. Data on population size are from 2007/2008 and represent the most recent census information (Ministry of Agriculture, 2009). Data on farm size, family size and main crops are based on Harvey et *al.,* (2014), while data on poverty levels come from INSTAT (2011).

Characteristics	**Variable**	**Ankeniheny Zahamena Corridor (CAZ)**	**Nosivolo**
Landscape characteristics	Size of study landscape (ha)	382,027	358,511
	Total population size (2007)	347,520	70,694
	Total number of villages	493	47
	Villages surveyed (population size)	Ambatohambana (846) Ambatoharanana (480) Ambinanisahavolo (211) Ambohimarina (450) Seranantsara (46) Androfia (100) Sakalava (100)	Vohitromby II (1613) Ambatomasina (483) Mahadio (821)
Farming systems	Farming systems	Slash and burn agriculture in highlands; irrigated agriculture in lowlands	Slash and burn agriculture in highlands; irrigated agriculture in lowlands
	Subsistence crops	Rice, corn and cassava	Rice, corn and cassava
	Cash crops	Ginger, cloves, coffee. white beans and bananas	Cloves, coffee, white beans and bananas
	Percent of households who have agriculture as main source of income	99	99
	Percent of farmers who cultivate less than 2 ha of land	77	91
Farmer characteristics	Mean family size (± SE)	5.4 ± 2.1	5.6 ± 2.5
	% of families who do not produce enough food to feed their families during the entire year	75	70
	% of population that is under the national poverty line ($1 dollar/day)	72	89

In order to assess the impacts of cyclone Giovanna on farmer livelihoods, we randomly selected a total of 10 selected communities (7 in CAZ and 3 in Nosivolo) from a list of areas which had been impacted by the cyclone. We surveyed more communities in the CAZ region than in Nosivolo because distinct regions of CAZ suffered different levels of exposure to the cyclone, while in Nosivolo, all communities were significantly impacted by the cyclone. In each of the ten villages, we randomly selected 10 households from a list of smallholder farmers and interviewed the wife and spouse in the same household (i.e., 200 people total, 100 men and 100 women). We interviewed both men and women because we were interested in seeing if men and women prepared for and/or responded differently to the cyclone. In cases where the head of the household was a woman, we also interviewed the most senior man in the same household.

The semi-structured survey was designed to collect information on farmer perceptions of the intensity of the cyclone, the impacts of the cyclone on their livelihoods, the preventative strategies used by farmers to prepare for the cyclone, the coping strategies used, and the support they received prior to and following the cyclone. All interviews were conducted inside or outside of the farmers' house and typically lasted 45 minutes. Male interviewers were responsible for interviews with the household head, while the women were interviewed by female interviewers. All household surveys were conducted in March, 2012, within a month of the cyclone's arrival. After each individual survey, we verified the data collected in each village through focal group discussions. All data were analyzed using descriptive statistics (means, percentages). Since responses from men and women were not statistically distinct, our summary statistics include answers from both men and women farmers (n=200 farmers).

3. **Results**

Preventative strategies used by farmers

Farmers undertook a variety of preventative actions to reduce the impact of cyclone Giovanna on their households (Table 2). Seventy percent of the farmers stored clean water to use following the cyclone. Other less common strategies included securing the roof with sandbags, storing food to ensure the family had food to eat following the cyclone, and moving rice seeds stored on the floor of their homes in plastic bags onto the table to ensure they would not be damaged by floods. Only 22% of farmers moved livestock to more secure locations (e.g., higher ground or inside home). Less than 20% of farmers sought refuge in

churches, schools or other buildings. On average, farmers implemented a mean of 1.9 preventative actions each.

Table 2. Actions taken by smallholder farmers to reduce the impact of cyclone Giovanna on their homes, agricultural production and families in the Ankeniheny Zahamena Corridor and Nosivolo, Madagascar. Numbers represent the percent of farmers who implemented a particular action.

Goal	**Preventative actions**	**Percent of farmers**
To protect homes	Secured roof	43
	Secured windows and doors	3
	Put up posts to support walls	6
To protect family members	Sought shelter (e.g., in a church or school)	18
	Moved family (children) to another region	13
	Ensured that the family had sufficient food reserves	37
To ensure food and water security	Stored food in a place where it would be protected from floods	32
	Stored clean water for use following the cyclone	70
To protect agricultural production	Stored rice seeds in a dry location to prevent damage from floods and rain	19
	Moved livestock to higher ground or safe location	22

Impacts of cyclone Giovanna on agriculture, housing, infrastructure and farmer livelihoods

A majority of farmers (87%) indicated that Giovanna was the strongest cyclone in the last decade and had significantly impacted their livelihoods. According to the farmers, Giovanna had a 'strong' impact on crop loss (81% of all farmers reported losing crops), flooding

(59%), schools and churches (57%), houses (56%) and road infrastructure (36 %; Table 3). Cyclone damage to infrastructure was significant: more than 80% of farmers suffered damage to their houses, such as collapsed or damaged roofs, or damaged walls and 18% of farmers reported that their houses had been completely destroyed. Farmers indicated that the houses which were most damaged by the cyclone were those made of ravinala and houses located in hill slopes or near rivers. Damage to public infrastructure was also significant: most local schools, churches and markets were closed for repair for one or more weeks following the cyclone. The direct impacts on livestock and injuries to people were considered less severe. The cyclone also affected the availability of non-timber forest product such as honey and wild yams that farmers regularly extract from forests, by destroying vegetation and making it difficult for farmers to access the forests.

Table 3. Farmer perceptions of the level of damage and impacts caused by cyclone Giovanna in the Ankeniheny Zahamena Corridor and Nosivolo, Madagascar. Numbers represent the % of farmers reporting a given level of damage. Damage levels are subjective categories identified by farmers, rather than quantitative damage levels.

Types of impacts	Levels of damage incurred			
	no damage	minimal	moderate	strong
Flooding	12	4	25	59
Damage to houses	3	9	33	56
Damage to schools and churches	13	11	21	57
Damage to roads	13	13	39	36
Crop damage	1	1	18	81
Injury or death of livestock	27	18	32	24
Injury of people	95	3	2	1
Availability of non-timber forest products from forest (e.g., honey, wild yams)	27	18	32	24

Cyclone Giovanna had particularly negative impacts on agricultural production and household food security. Almost 90% of farmers indicated that their rice fields were damaged by the cyclone (Table 4). The level of damage was variable, with some farmers reporting that

they lost less than 25% of their crop, while others reported they had lost more than 75%. The location of rice fields in the landscape appeared to have little impact on the damage sustained.

Roughly half of the farmers also lost stored grains to the cyclone (Table 4). For many farmers the loss was significant: 39% of the farmers who had stored grains lost more than three quarters of their stored food supplies to the cyclone. As a result of crop damage and the loss of stored grains, 89% of farmers indicated that their household did not have sufficient food to meet their current needs. Thirty eight percent of the farmers indicated they lacked sufficient food for 3-5 months following the cyclone, while an additional 47% indicated they would lack food for >6 months.

Table 4. Farmer assessments of the impacts of cyclone Giovanna on agricultural production, food stores and household food security in the Ankeniheny Zahamena Corridor and Nosivolo, Madagascar.

Variable	Response	**% of farmers**
Percent of farmer's rice crop fields damaged by cyclone	None	5
	<25%	10
	25-50%	21
	50 -75%	22
	>75%	38
Location of rice fields which were most affected by the cyclone*	Valley	22
	Floodplain	9
	Hill slope	20
	All	49
Percent of farmers whose stored grains were damaged by the cyclone (n=200)		70
Percent of stored grains that were damaged by the cyclone (n =140)	<25%	24
	25 -50%	20
	50 - 75%	18
	>75%	39
Percent of farmers with insufficient food to feed their families following the cyclone (n=179)		89

Percent of months that households lacked sufficient food to feed their households following the cyclone (n=178)	2 months	3
	3 to 5 months	38
	>6 months	47

*percentages do not add to 100 for this question as farmers mentioned multiple locations as being affected.

The cyclone also had significant impacts on the availability of clean drinking water and farmer health. Approximately three quarters of the farmers did not have access to a clean drinking water following the cyclone, as the rivers, streams and wells where they collect water had mud and debris. As a result, most waterborne diseases, such as diarrhea, were common in the month following the cyclone (Table 5).

Table 5. Impacts of cyclone Giovanna on water availability and health of smallholder farmers in Corridor and Nosivolo, Madagascar.

Impact		**Percent of farmers**
Lacked access clean drinking water after the cyclone (n =129)		35
Type of available water source for drinking and cooking, following the cyclone (n =132)	A public standpipe with tap	12
	A public standpipe without tap	20
	A standpipe with/ without a pump	7
	Well	10
	Rivers	36
	Lake or pond	5
	Other (stream, rainfall)	11
Suffered diseases in the last month following the cyclone (n=200)		66
The most common diseases reported following the cyclone (n=130)	Diarrhea	54
	Cholera	2
	Other (flu, cough, malaria)	45

Coping strategies used by smallholder farmers

Farmers coped with adverse impacts of cyclone Giovanna on agricultural production, food security and income loss/increased costs in several ways (Table 6). Most farmers (71%) replanted crops in the fields that had been damaged, however a subset of farmers (27%) decided not to replant until the next season and 3% of farmers abandoned their crop fields

due to flooding and siltation. Restoring flooded croplands and replanting crops was time consuming: 49% of the farmers indicated that they would have to spend more than one month replanting fields that had been damaged by the cyclone.

Table 6. Coping strategies used by smallholder farmers in Nosivolo and CAZ, Madagascar, to deal with damaged crops, increased food insecurity and income loss due to cyclone Giovanna.

Issue	Coping strategy used	Percent of farmers
Damaged agricultural lands (n= 196)	Replanted fields	70
	Waited to replant in the next season	27
	Abandoned fields	3
	Changed the type of crops	1
Food insecurity (n=187)	Bought additional food	85
	Reduced food consumption of staple food (quantity or frequency of meals)	82
	Harvested wild food	40
	Received food from relatives	16
	Received food from neighbors	10
	Received food aid from government and NGOs	5
Income loss and additional costs associated with cyclone damage (n=189)	Sent an adult household member to get an outside job	51
	Borrowed money from friends	11
	Made children work more on the farm	8
	Sent older children away to work	7
	Took boys out of school	3
	Took girls out of school	3
	Leased land to other farmers	1
	Took out a loan	1

Farmers coped with the food insecurity caused by the cyclone by reducing food consumption, buying additional food and receiving food aid from neighbors or relatives (Table 6). Only 5% received food aid from the government. In addition, more than half of the farmers reported sending an adult household member to get a temporary outside job to generate income to buy food and pay for necessary expenses. Other, less common, strategies for increasing household income included borrowing money from friends and making children work more on the farm.

Almost all farmers had to rebuild or repair their homes following the cyclone. In most cases, farmers collected materials (timber, Raphia, Ravinala, etc.) directly from the forest to rebuild their homes, or bought these materials from other farmers who had collected these materials in the forest and had carts to transport the materials from the forest to the village. In addition, a subset of farmers had to buy additional materials (especially wood and nails, but in a few cases, also tin roofs, cement, and concrete) to rebuild their homes. The total costs of local materials for rebuilding the houses varied across farmers, with an estimated mean of 50,000 ± 11,519 Ariary (or 25 ± 5.8 US dollars). Farmers paid for these costs by selling crops (35% of farmers), performing off-farm labor (25%), selling small livestock (24%), using savings (18%), or selling other assets (13%) such as radio sets or sewing machines. Less than 8% of farmers borrowed money or took out a loan to cover these costs. All farmers reported relying on their extended families and, to a lesser degree, on friends and neighbors (30%) to help them collect local materials and providing labour to rebuild their houses, with rebuilding taking anywhere from a couple of days (31% of farmers) to more than a month (28% of farmers) for those farmers who have houses made of cement or bricks. Only 5% of the farmers received any food, building materials or financial support from formal organizations.

Farmers identified several strategies which could have helped reduce the impacts of cyclone Giovanna on their livelihoods. These approaches included building sturdier houses (mentioned by 95% of farmers), storing more grains prior to the cyclone (84%), protecting livestock (76%) relocating to the shelter earlier (67%), moving temporarily to another location (49%) and selling stored crops prior to the cyclone (34%)

4. Discussion

4.1 Impacts of cyclones on livelihoods of smallholder farmers

Our study highlights the devastating impacts that cyclones can have on the livelihoods of smallholder farmers in Madagascar and the urgent need to help these farmers better prepare for and cope with these impacts. While previous studies in Madagascar have documented the overall damage (e.g., numbers of houses, roads and bridges destroyed and area of crops lost) and costs of cyclones at the national or regional scale (BNGRC, 2012), this is the first study to our knowledge to examine in detail how Malagasy smallholder farmers prepared for the cyclone, how their livelihoods were impacted, and how they coped with these impacts. Our study suggests that cyclones pose a significant challenge for Malagasy smallholder farmers, causing significant damage to crop fields, loss of stored grains, damage to houses, increased food insecurity, reduced access to clean water, and increased incidence of water-borne diseases. In addition to the immediate impacts, cyclones are likely to continue to affect smallholder farmers for months, possibly years, into the future, as the loss of agricultural productivity and associated decline in food security and income generation further exacerbate their already precarious living conditions. The recurring nature of cyclones makes it extremely difficult for farmers to replant crops, rebuild houses and recover before another cyclone hits. Studies of other cyclone-prone developing countries have similarly highlighted the impacts of cyclones in exacerbating rural poverty, stalling rural development, and amplifying the vulnerability of smallholder farmers who are already poor and vulnerable (e.g., Gbetibouo and Ringler 2009; Bahinipati and Venkatachalam, 2015; Mutabazi et al., 2015).

Malagasy smallholder farmers are vulnerable to cyclones and other extreme weather events for a variety of reasons. First, Malagasy smallholder farmers are extremely poor (with most living under the national poverty line of one US$ per day), rely almost entirely on agriculture for their livelihoods, and suffer chronic food insecurity even in regular, non-cyclone years (WFP and UNICEF, 2011, INSTAT 2011). The regular ‘lean’ season in Madagascar occurs between October and March (Ministry of Agriculture 2004) and the majority of farmers lack sufficient food during this time. In CAZ and Nosivolo, smallholder farmers are food insecure for an average of 3.7 months per year (Harvey et al., 2014). Cyclones tend to hit during the peak of the lean season, further exacerbating food insecurity and extending the lean season by several months. When crops are damaged by strong cyclone winds and associated flooding, farmers are left both without sufficient food and without the means to generate income to buy

food. Since farmers usually have little or no savings, they often fall in further hardship. These interlinkages between poverty, food insecurity and vulnerability to climate risks have also been documented elsewhere (e.g., Kelly and Adger, 2000; Mutabazi et al., 2015).

Malagasy smallholder farmers are also highly vulnerable because they lack access to extension and formal support systems which could help them better prepare and cope with the impacts of cyclones. Like many remote rural regions in Madagascar, CAZ and Nosivolo receive little government support and are serviced by few organizations. Farmers in these regions rarely receive any technical support for agricultural production or disaster relief following cyclones (Harvey et al., 2014). While other more accessible regions received emergency support such as food, building materials and essential supplies from both the national government and disaster relief organizations (e.g., CARE International and Catholic Relief Services) following cyclone Giovanna (BNGRC, 2012), farmers in CAZ and Nosivolo received no support in the month following the cyclone's devastation. This lack of formal support reflects both the remote location and poor road infrastructure of the study sites, as well as the limited resources and capacity of the Malagasy government to respond to natural disasters. During the recent political crisis (2009 to 2014) in Madagascar, most donors froze their development aid to the country resulting in an estimated 600 million euros (824 million USD) loss (UNHRC, 2011). As a result, the Malagasy government now has even less money available for disaster relief efforts (Clayton, 2012).

4.2. Strategies for reducing impacts of cyclones on smallholder farmers

4.2.1. Reducing the vulnerability of smallholder farmers and enhancing resiliency

In Madagascar, reducing the impacts of cyclones on smallholder farmers will require addressing three key and interrelated issues. First, there is a need to reduce the inherent vulnerability of smallholder farmers by improving their living conditions, food security and access to basic services. This is a daunting challenge given high levels of poverty and food insecurity among farmers, limited government resources for addressing poverty and food security issues, poor road infrastructure, limited technical support for coping with disaster risks and limited extension services for farmers (Zeller et al. 1999; INSTAT, 2011; WFP and UNICEF, 2011; BNGRC, 2011). Major investments are urgently needed to improve health services, infrastructure, education, and housing, alleviate poverty, improve food security,

provide extension services to farmers and promote the development of livelihood options that are resilient to climate change (Randrianarisoa and Minten, 2001; Barrett et al., 2004; WFP and UNICEF, 2011). Studies of smallholder farmers elsewhere (e.g., Bryan et al., 2009; Mutabazi et al., 2015, Bhatta and Aggarwal, 2016) have similarly highlighted the urgency of reducing the underlying vulnerability of smallholder farmers to climate change by tackling poverty and food insecurity, fostering resilience to climate change shocks, developing social safety nets and mainstreaming climate adaptation into rural development initiatives. In particular, the provision of agricultural extension services to farmers to help enhance agricultural productivity, diversify their income generating activities and encourage the adoption of adaptation measures will be critical for reducing their vulnerability to cyclones and other climate risks (Bahinipati and Venkatachalam, 2015).

4.2.1. Enhancing farmer preparedness for cyclones

Second, there is an urgent need to help smallholder farmers prepare for upcoming cyclones by providing them with more detailed, advance information about incoming cyclones, and about the precautionary measures they should take to minimize potential cyclone impacts. In Madagascar, the Meteorological Service is in charge of providing cyclone warnings to the national broadcasting company, who then announces this information to the public. While most of the smallholder farmers in our study sites heard about cyclone Giovanna from the National Broadcasting Service of Madagascar, the warning arrived only 1-2 days before the cyclone struck, giving them little time to prepare (IRIN, 2013). In addition, most farmers were unaware that this would be the strongest cyclone since 1994 to hit the eastern coast of Madagascar and did not expect significant levels of damage (Raonivelo, 2013). As a result, the level of preparation among farmers was low. Earlier and more detailed alerts are needed to convey the expected magnitude of upcoming cyclones and to provide specific instructions to farmers on how to best prepare. Improving access to better climate information is known to be an effective means of increasing awareness of climate risks and helping farmers make informed decisions about how to prepare for cyclones and other extreme weather events (e.g., Stone and Meinke, 2006; Mtambanengwe et al., 2012).

Additional training and outreach is also needed to help ensure farmers are aware of and implement effective preventative actions and adaptation measures that could enhance their resiliency to climate risks. Madagascar's National Strategy for Reducing Risks and Disasters

(UNDP/CNS, 2010) recommends that farmers prepare for cyclones by storing enough food and clean water for the duration and immediate aftermath of the cyclone, securing homes and other assets to minimize potential damage, and seeking refuge in secure buildings to prevent human injury and death, however many farmers did not follow these instructions and were therefore unprepared when cyclone Giovanna arrived. Finding ways of preventing damage to houses is a particular challenge. While many farmers secured their roofs in preparation for the cyclone, more than 80% still suffered significant damage to their homes. It is well known that concrete or brick houses are less likely to be damaged by cyclones, but few smallholder farmers are able to afford them. In addition, in focal group discussions farmers indicated that they prefer the traditionally Raphia and mud homes because although they are more likely to be damaged by cyclones, they can be easily repaired using local materials collected from the forest and therefore cost less to rebuild. Encouraging farmers to seek shelter in churches, schools and other sturdy building is also challenging, as farmers are reticent to leave their homes and move to shelters for fear of having their household possessions stolen while they are gone (RFI, 2015).

There are a number of other actions that could also help minimize potential impacts on smallholder livelihoods and farming systems. For example, farmers should ensure that any stored seeds or harvested crops are carefully protected from wind or flooding damage by storing them in waterproof bags or receptacles, and moving them out of the path of potential flooding. Most farmers store seeds in plastic bags on the floor of their homes, so simple actions such as ensuring the bags are waterproof and placing them high on the family table or storing seeds in waterproof contains could prevent unnecessary seed loss. Community granaries could be strategically located in less exposed areas to allow storing grains in safety. Farmers should also ensure irrigation channels and drainage ditches are well maintained to minimize flooding of crop fields, and, where necessary, dig additional ditches in anticipation of the cyclone to divert flood waters. Restoring riparian areas along rivers, reforesting upland slopes and enhancing vegetative complexity within field could also help reduce flooding from cyclones (Holt-Gimenez, 2001, Palmer et al., 2008). There is also an urgent need to ensure that the remaining forest areas are conserve, as the forests serve a key safety nets for smallholder farmer's following cyclones, providing them with emergency food supplies and building materials for home reconstruction (Harvey et al., 2014).

4.2.3. Creating formal safety nets for smallholder farmers

Finally, there is a need for formal safety nets (e.g., government programs, development organizations, disaster relief agencies, etc.) which can provide farmers with emergency food aid, credit or money for meeting their immediate food needs, building supplies for rebuilding homes, and seeds, tools and other agricultural inputs for replanting their crops. These formal safety nets should also provide access to clean water supplies immediately following the cyclone and help clean the stagnant water in wells following cyclones to avoid them serving as breeding grounds for mosquitoes and other disease-spreading insects (Relief Analysis Wire, 2012). Malagasy farmers currently rely almost exclusively on extended families and neighbors for support, but these informal networks are incapable of mitigating the substantial impacts of cyclones on local livelihoods. More formal and better financed disaster relief programs and institutions could significantly help reduce both the immediate and long-term effects of cyclones on local communities. Better access to agricultural extension services will also be key for improving farmer knowledge and use of adaptation strategies (such as improved management of soil and water resources, timing of crop planting, etc.,(Mtambanengwe et al., 2012; Bahinipati, 2015; Bahinipati and Venkatachalam, 2015) that could help minimize the impacts of future cyclones on farming systems. Improving access to formal support networks and extension services is a necessary step for breaking the vicious cycle of poverty, food insecurity and vulnerability that currently entraps smallholder farmers (Rahman and Klees, 2014; Bahinipati. 2015)

5. Conclusion

Our study suggests that cyclones pose a tremendous challenge for Madagascar's large population of smallholder farmers. Cyclone Giovanna inflicted substantial damage to crops and homes, significantly increased food insecurity, and decreased availability of clean water to smallholder farmers. These impacts exacerbate the already very high levels of poverty and food insecurity among Malagasy smallholder farmers. While smallholder farmers have a wide number of coping strategies for dealing with the aftermath of cyclones, they remain highly vulnerable to these impacts and suffer significant impacts when cyclones hit. There is an urgent need for governments, donors, and development organizations to reduce the inherent vulnerability of Malagasy smallholder farmers to cyclones and other climate risks by

improving early warning systems, helping farmers prepare for upcoming cyclones, creating formal safety nets to help farmers access food, water and other essential supplies following cyclones, and promoting the use of adaptation measures to enhance the resiliency of farming systems to future climate shocks. These actions are critical for not only for reducing smallholder vulnerability to cyclones and other climate shocks, but also for tackling the unacceptably high levels of food insecurity and poverty among Malagasy smallholder farmers.

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DISCUSSION ET RECOMMANDATIONS

La vulnérabilité des ménages ruraux face au changement climatique se trouve presque dans toutes les 22 régions de Madagascar (Instat, 2011, WFP & UNICEF, 2011). Elle est également connue dans le monde entier, surtout en Afrique (Hertel & Rosch, 2010 ; Sanchez, 2005). Les différents facteurs qui affectent cette vulnérabilité (la pauvreté, les aléas climatiques, la déforestation, l'insuffisance des infrastructures agricoles,…) sont déjà décrits dans les articles ci-dessus et ils s'interfèrent et s'interconnent. La lutte contre la vulnérabilité des ménages ruraux doit s'adresser aux diffèrent facteurs sus –cités et c'est une responsabilité de toutes les parties prenantes au niveau local, régional et national (Etat, Fokontany, autres services publiques pour le développement et ONGs de développement et de conservation).

L'Etat Malgache a développé et mis en œuvre des stratégies et des programmes pour réduire cette vulnérabilité, mais leurs impacts sur la résilience des ménages ruraux face au changement climatique sont encore marginaux. Les ressources financières et les compétences techniques des agents de l'Etat et des collectivités décentralisées ne sont pas suffisantes pour adresser de manière pertinente les enjeux. Au niveau de base, ce sont les fokontany qui jouent un rôle prépondérant dans la gestion des risques et catastrophes : ils donnent l'alerte en utilisant des mégaphones ou autres moyens comme les cloches d'églises (les communautés se rendent `à l'église ensuite pour s'informer). Ils gèrent également les informations sur les risques et facilitent les travaux de secours d'urgence. Mais par rapport à l'ampleur des risques, les moyens et les capacités mobilisables au niveau des fokontany sont très limitées.

Quoique plus flexibles que les services étatiques, les ONG de développement interviennent sous forme de projets, qui n'ont pas toujours un objectif de réduction de vulnérabilité, mais dans des thématiques sectoriels plus globaux (développement rural, conservation, gouvernance, etc). Les ONGs ont des zones d'intervention limitées, et beaucoup d'entre elles sont loin des zones fréquemment atteintes par les risques et catastrophes naturels, ou disposent des moyens logistiques nécessaires pour une intervention efficace, encore moins de ressources financières pour asseoir une approche de réduction de vulnérabilité impliquant les bénéficiaires sur le long terme.

Enfin la vulnérabilité des ménages ruraux dépend de leur mode d'existence, dont le niveau de dépendance aux ressources naturelles et aux services écosystémiques, et les interrelations entre les forêts et les modes de vie des ménages qui vivent en lisière de forêts ont toujours été fortes (Gorenflo L.J., 2011). La réussite ou l'échec des projets de développement ou de conservation dépendent de la stabilité ou de la précarité de ces interrelations

La partie ci-dessous est composée par des recommandations pour améliorer la résilience des ménages ruraux face au changement climatique. Deux domaines différents de recommandation ont été identifiés: celles qui visent à réduire les risques agricoles et celles qui sont orientés vers le maintien du capital naturel de biens et services que sont les forêts, par une adaptation basée sur les écosystèmes.

Recommandations pour réduire les risques sur l'agriculture

Augmenter la productivité et la résistance des systèmes de production des petits exploitants agricoles constitue un énorme défi qui exigera un appui et une action technique, financier et politique importante et durable aux niveaux nationaux et locaux. Cependant, nous soulignons ici quelques approches spécifiques à moindre coût qui pourraient entrainer l'amélioration des moyens de subsistance des petits cultivateurs du pays:

Fournir un appui technique, du renforcement des capacités et des intrants agricoles aux cultivateurs pour les aider à améliorer globalement la productivité et la résistance des systèmes de production des petits exploitants agricoles. Il est urgent d'améliorer la productivité des systèmes de production des petits exploitants agricoles pour que les cultivateurs des villages éloignés produisent plus de nourriture, soient plus en sécurité sur le plan alimentaire en général, génèrent plus de revenus et soient moins vulnérables aux chocs affectant leur production agricole.

Développer des filets de sécurité formels et faciliter l'accès des petits exploitants agricoles aux crédits. Il y a un besoin urgent de mettre en place des filets de sécurité formels et aussi de renforcer les réseaux de sécurité informels pour s'assurer que les agriculteurs puissent obtenir du soutien quand ils en ont besoin. La plupart des ménages des petits exploitants agricoles n'ont actuellement pas accès aux filets de sécurité formels vers lesquels ils pourraient se tourner en cas de besoin. Ils restent hors d'un crédit formel ou du système bancaire et sont dans l'impossibilité d'accéder aux crédits formels ou aux prêts auprès d'institutions de microfinance. Dans les communautés étudiées, moins de 2 % ont déclaré avoir reçu de l'aide

des institutions locales après des catastrophes naturelles. En outre, des organisations et des associations locales pourraient jouer un rôle beaucoup plus important pour réduire la vulnérabilité des cultivateurs aux risques agricoles en garantissant l'utilisation des meilleures pratiques de gestion agricole, en aidant les cultivateurs à mieux se préparer aux phénomènes climatiques extrêmes et en fournissant du secours d'urgence après de tels phénomènes et en construisant des greniers communautaires pour stocker en toute sécurité les produits agricoles. Des épargnes villageoises et des groupes de prêts, par lesquels les membres mettent en commun des ressources et prêtent aux membres dans le besoin, sont également des solutions à moindre coût qui pourraient réduire les pires effets de la période de soudure ou des phénomènes climatiques extrêmes, tout en créant des fonds locaux dans lesquels les petits exploitants agricoles puisent pour d'autres activités de développement.

Investir dans des infrastructures agricoles locales à petite échelle pour améliorer la productivité agricole et améliorer la résistance des systèmes de petites exploitations. Des investissements dans des projets locaux d'infrastructure à petite échelle et sur la base des matériaux locaux, tels que l'amélioration des drainages et des systèmes d'irrigation ou des lieux de stockage des cultures pourraient aider les petits exploitants agricoles à accroître la production agricole et à mieux protéger leurs récoltes. Beaucoup de canaux d'irrigation existants dans les zones de l'étude sont en mauvais état et nécessitent un entretien urgent. De même, quelques ménages ou communautés seulement disposent de lieux de stockage adéquats pour leurs récoltes. Alors que les petits cultivateurs de Madagascar sont très désireux de construire des infrastructures locales (drainage local ou canaux d'irrigation), ils ont rarement les fonds nécessaires pour financer ces activités. Les agences et organismes gouvernementaux travaillant dans les régions éloignées pourraient promouvoir une telle infrastructure à petite échelle à travers le développement de petites subventions et crédit aux cultivateurs ou aux associations d'agriculteurs locales, à travers le développement de nouveaux systèmes de financement ou l'établissement de régimes de vivre contre travail qui peuvent fournir des emplois et de l'aide alimentaire aux cultivateurs en contrepartie de leur travail.

- Les recherches actions dans la promotion à grande échelle de l'agriculture climato-intelligent et la mise en œuvre du programme de développement par l'approche participative sont indispensables pour mieux comprendre les différentes causes des risques, d'identifier les lacunes et de définir les stratégies de réponses appropriées et mettre en échelle la mise en œuvre de ces stratégies.

Recommandation pour maintenir le capital naturel de biens et services

Les stratégies su scitées ne seront efficaces que si le potentiel des forêts à fournir les services écosystémiques d'approvisionnement et de régulation ne soit maintenu.

- L'implication des paysans dans les activités de conservation, de la restauration et de la gestion durable des écosystèmes naturels sont donc essentielles pour améliorer les moyens de subsistance des petits paysans face aux catastrophes naturelles. L'approche participative dans tout le cycle du projet de conservation ou de gestion des ressources naturelles sont indispensable pour assurer son succès.

- Renforcement de la communication a tous les niveaux. Les décideurs politiques et les parties prenantes devraient reconnaître les liens étroits entre les écosystèmes naturels et les subsistances des cultivateurs. Les écosystèmes naturels servent comme filets de sécurité après les catastrophes naturelles. Ces décideurs politiques doivent s'assurer que les stratégies d'adaptation, de développement rural, de l'agriculture, de la réduction de la pauvreté promeuvent explicitement la conservation et la gestion durable des écosystèmes naturels au sein des paysages agricoles.

- Le zonage et la matérialisation des limites des aires protégées sont indispensable pour que la population locale puisse connaitre les différentes zones : Noyau dur de l'AP et la zone tampon qui peut être composée par la zone d'occupation contrôlée, la zone d'utilisation durable et la zone de services.

- La gestion des ressources naturelle doit tenir compte : a) le respect des droits de l'homme b) recevabilité et la transparence, le partage juste et équitable des bénéfices, l'effectivité et la subsidiarité. Ceci conduit à la bonne gourvance de gestion de ces ressources naturelles qui assure le bien être humain et la protection des services environnementaux.

A l'échelle mondiale, la pratique d'adaptation sur la base des écosystèmes est fortement suggérée par les Nations Unis. Le concept d'EbA est apparu récemment dans les discussions et recherches académiques sur l'adaptation au changement climatique. Sa considération fait référence au capita naturel qui est valorisé de plusieurs manières à travers le monde pour le bien être humain en général. Cette valorisation se fait sur la base des biens et services fournie par les écosystèmes, dont les forêts. Des recherches approfondies sur l'application de cette adaptation basée sur l'écosystème sont encouragées pour démontrer leur efficacité à Madagascar parce que les décideurs politiques devraient reconnaître les liens étroits entre les écosystèmes naturels, les subsistances des petits exploitants agricoles et leur adaptation au changement climatique.

CONCLUSION GENERALE

Madagascar est exposé régulièrement à deux risques climatiques majeurs : la sécheresse et les cyclones. La fréquence ainsi que l'intensité ces deux phénomènes vont s'accentuer dans le futur, avec le changement climatique. Il en est de même pour leur intensité. Déjà actuellement, les sécheresses ont des cycles de plus en plus courts dans le sud de l'île, et les cyclones intenses sont de plus en plus fréquents, frappant principalement les zones côtières.

En outre, Madagascar est un pays pauvre. Cette pauvreté est essentiellement rurale. Les petits agriculteurs malgaches vivant en lisière de forêts étaient restés dans un modèle archaïque de mise en valeur des ressources, pratiquant une agriculture de subsistance faiblement capitalisée, et qui s'étend de manière continue sur les aires forestières. Cette précarité de mode d'existence sera également exacerbée par le changement climatique.

Cette étude a pour objectifs d'analyser les impacts du changement climatique sur les moyens d'existence des petits agriculteurs et d'évaluer leur adaptation au changement climatique en prenant en considération l'utilisation des ressources naturelles. Les résultats nous montrent que les deux premières hypothèses citées dans la partie introduction générale sont confirmés.

Le chapitre 1 sur l'extrême vulnérabilité des petits agriculteurs aux risques agricoles et au changement climatique a pu montrer que les petits agriculteurs ont toujours été exposés aux risques agricoles et au changement climatique. Les principaux risques mentionnés par les ménages sont la perte des récoltes sur pied et des produits stockés, la destruction des habitations, la perte des champs de culture et la résurgence de certaines maladies (paludisme, diarrhée). La sous-capitalisation du secteur maintient ces risques à un niveau élevé, car les ménages sont démunis et leur capacité pour se relever après qu'un risque se produise est faible. Le changement climatique se manifestant par des évènements climatiques majeurs de plus en plus fréquents ou de plus en plus intenses, se révèle alors comme un facteur amplifiant les risques agricoles.

En effet, les petits agriculteurs dépendent très fortement du capital naturel pour leur mode d'existence : la fertilité naturelle des sols, le minimum d'aménagements, et la saisonnalité naturelle des pluies. Ils ont un accès limité aux marchés et sont exposés à la volatilité des prix

des produits de rente. Ils connaissent généralement une période de soudure régulière, et parfois l'insécurité alimentaire. L'isolement géographique et le manque d'accès aux filets de sécurité sont, par ailleurs, des facteurs qui pèsent sur leur situation déjà précaire. Avec le changement climatique, tous ces facteurs se conjuguent pour rendre les petits agriculteurs extrêmement vulnérables. Ils sont alors exposés à des pertes de récoltes, des pertes de grains stockés sommairement dans des endroits peu sécurisés, des maladies, et surtout à l'insécurité alimentaire qui risque de devenir chronique. Cette situation est confirmée au niveau de l'échantillon étudié, et le cas n'est sans doute pas isolé au niveau du pays. Les stratégies de facto adoptées par les petits agriculteurs pour faire face aux risques climatiques sont faiblement efficaces. Les recours sont (encore) le capital social existant (les familles, le voisinage), qui sont en général frappés par les mêmes risques. Les petits agriculteurs se retrouvent ainsi entraînés dans une spirale de dégradation des modes d'existence, entretenue par les risques agricoles et aggravée par les risques climatiques. Ces résultats confirment la première hypothèse comme quoi la variabilité climatique a des impacts sur les modes de vie des populations rurales des villages reculés, particulièrement sur leur économie et leur sécurité alimentaire.

Le chapitre 2 nous a montré que l'adaptation des petits agriculteurs au changement climatique est fortement liée à utilisation des produits forestiers. Pour faire face aux risques, les petits agriculteurs ont adopté une stratégie peu innovante : la collecte des aliments nécessaires à la subsistance dans la forêt, et l'extension des terres de culture vers les terres forestières. En effet, les forêts sont considérées comme un réservoir de biens et de services qui soulagent les impacts du changement climatique, et les terres forestières sont relativement fertiles. Cependant, le fait même de convertir les forêts en zones agricoles (déforestation et culture sur brûlis) et la collecte non durable de produits forestiers entament sérieusement la capacité des forêts à assurer les différents services écosystémiques que ceux-ci apportent pour les modes d'existence et le bien être humain

Déjà, actuellement, même les petits agriculteurs perçoivent une déplétion des biens et services assurés par les forêts et une diminution palpable de la couverture forestière : le réservoir est en train de se vider. Les produits forestiers qu'ils reconnaissent utiliser sont de plus en plus rares (bois, fibres, plantes médicinales, etc.). Les répondants aux enquêtes réalisées lors de cette étude en font en général le constat. Cette raréfaction est due à l'accroissement démographique, à la surexploitation pur suppléer les besoins en nourriture ou en revenus d'appoint, et aux besoins devenus cruciaux après les catastrophes naturels. Etant

donné le niveau de pauvreté des ménages et leur dépendance aux forêts, cette raréfaction affecte les modes de vie des ménages. Durant une partie de l'année, certains ménages sont amenés à s'établir dans des campements de fortune en pleine forêt, pour disposer plus facilement de produits forestiers et être plus proche des aires à défricher.

Le chapitre 3 est une étude de cas concernant les stratégies d'adaptation par des petits agriculteurs pour le passage du cyclone Giovanna dans le Corridor Ankeniheny Zahamena et dans la zone de Nosivolo. C'était un cyclone intense, suivi de fortes inondations. Au niveau des petits agriculteurs, les récoltes, les champs de culture et les habitations sont sévèrement touchées. La stratégie adoptée par les paysans consistait à recourir aux produits et services des forêts : le bois pour reconstruire les cases, l'alimentation d'appoint d'origine forestière pour pallier à l'insécurité alimentaire, et l'extension des champs de culture dans la forêt pour disposer à terme de plus de récoltes. Si la culture sur brûlis est traditionnellement entretenue par les besoins de subsistance, elle est motivée actuellement par le besoin additionnel de faire face aux risques climatiques. On se rend compte que les ménages agriculteurs ont utilisé une variété de stratégies d'atténuation de risques, mais celles-ci ne sont pas efficaces à cause de la vulnérabilité intrinsèque des agriculteurs eux-mêmes, qui découle de leur pauvreté et d'une marginalisation généralisée.

Cette stratégie est payante à court terme, car elle permet aux petits agriculteurs de passer l'année et de subvenir à leurs besoins de base. Pourtant, une telle utilisation du capital nature n'est pas durable, et l'épuisement des services et des biens écosystémiques fournis par les forêts ont des conséquences plus graves sur le long terme. Elle menace les modes d'existence même des petits agriculteurs.

Le capital naturel et les services ecosystemiques constituent le garant même du mode d'existence des petits agriculteurs et constituent un filet de sécurité naturel face aux risques. De plus les réponses au changement climatique que l'on trouve dans les stratégies contiennent la plupart du temps un renforcement des infrastructures et du capital physique (pour supporter des crues centenaires ou pour supporter des cyclones intenses par exemple). Ces solutions « dures » sont en général très coûteuses, et avec des durées de vie limitées. C'est alors que le capital est considéré comme une des composantes clés du capital du ménage, à même de répondre plus efficacement au changement climatique, surtout pour les pays en développement. Ceci pour trois raisons :

- La vitesse du changement climatique est lente (même si les variabilités atteignent des extrêmes). L'augmentation de température est de 1 degré Celsius sur quelques décennies. Ce qui est à la mesure des écosystèmes, dont la restauration naturelle et la reconstitution des fonctions et services de base sont également lentes.

- Le coût de l'adaptation : comparée au coût du capital physique, l'investissement sur le capital naturel est de faible coût. Il est à la portée des pays pauvres comme Madagascar.

- Le respect du conceptuel vernaculaire : comme les ménages ont toujours considéré la capital naturel (dont les forêts) comme refuge ou comme réservoir de secours pour les évènements inattendus et les catastrophes,

Ce capital naturel est reconnu comme la base des conditions d'existence des ménages à Madagascar. Une grande partie de celui-ci jouit d'un statut de protection. Il n'est pas prouvé que la première motivation de la mise en place des aires protégées et la protection/gestion durable des ressources naturelles à Madagascar soit pour l'adaptation des communautés rurales au changement climatique. La diversité biologique, l'endémicité et l'intensité de concentration de ces espèces biologiques ont toujours été mises en avant. Pourtant, il s'avère aujourd'hui que ces mesures sont parmi les plus utiles et les plus précurseurs dans l'adaptation au changement climatique, pris depuis maintenant près d'un siècle. Ces décisions (et la continuité de ces décisions) constituent une serindipité ou hasard heureux.

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Annexes

Annexe .1.Fanombanana ny harefon'ny tantsaha madinika

Fanontaniana: karazany voalohany: fanadihanihana ny lohany fianakaviana

Fandihadiana ny tokatrano tantsaha mombany tetik'asa fanombanana ny paik'ady entin' ireo fokonolona osa na vondron'olona tsotra hiady loza miantraika amin'ny famokarana

Conservation International, November etDecember 2011
Tanjona: Ny tanjona ankapoben'ity fanadihadiana ity dia ny ahafantarana ny paikady amin'ny velontena ny tantsaha kely sy sahirana eto Madagasikara, ahafantarana ireo loza misy izay miantraika amin'ny famokarana sy ny velontena, ary ahafantarana ireo paik'ady goavana ampiasain'ireo tokatrano tantsaha kely fidiram-bola eto Madagasikara, manahoana ny fahombiazan'ireo paikady ireo, inona no sembana tsy nahatomombana azy ireo ary ahoana no mety ahatomombana ireo paikady ireo. Anisany tanjona ihany koa ny ahafantarana ny andraikitr'ireo fikambanana isan-karazany, vondron'olona ifotony mba hanalefahana ny fiantraikany loza ary hanampy ny tokantrano @ fanan-tanterahana ny paikady entina miady @ olana.

Ity fanadihadiana ity dia natao mba hamaliana ireto fanontaniana manaraka ireto

a. Inona no olana goavana izay misy fiantraikany @ fomba famokarana, ahoana no fiantraikan'izany @ famokarana sy ny velontena ny tantsaha?

i. Impiry ary manao ahoana/ hatraiza ny fisehon'ny loza mahakasika ny famokarana
ii. Manao ahoana ny fiantraikan'ireo loza ireo amin'ny famokarana sy ny velontena? manao ahoana ny heriny?
iii. Ireo loza ireo ve dia misy fiantraikany amin'ny fokonolona rehetra sa ny sasantsasany ihany? (oh: samihafa ve ny fiantraikany @ ireo karazana tantsaha?mitovy ve ny fiantraikany @ lahy sy ny vavy?
iv. Iza no tena osa? Satria nahoana? Ahoana ny fahafahana miatrika na mamolatena mba hizatra ny loza?

b. Inona avy ireo karazana paikady entina miatrika na hiadiana @ loza mahakasika ny famokarana ampiasainy tantsaha Malagasy?

i. Inona avy ireo paik'ady hampihena ny loza na hiatrehana ny loza ampiasaina ary nahoana?
ii. Iza ao amin'ny fiarahamonina no mampiasa ireo paikady ireo? Iza no mampiatra azy? Samihafa ve ny paikady hampiasainy vehivahy sy ny lehilahy?
iii. Ahoana ny hampahomby ireo paikady hiadiana sy hizarana ny loza?
iv. Paikady inona, raha misy, no ampiasainy tantsaha mba hizarana ny fiovana maharitra ny toetrandro na loza?

c. Inona no mety ho andraikitry ny fikambanana na vondron'olona ifotony mba hanome hery ireo tantsaha kely fidiram-bola mba hampahomby ireo paikady entina miatrika ny loza mitranga mahakasika ny famokarana sy mba hitazomana ny famokarana sy ny velontena eny ambanivohitra.

i. Inona no karazany fikambanana na vondron'olona ifotony no itodihany hangatahana fanampiana?
ii. Inona no fanampiana omen'ireo fikambanana na vondron'olona ifotony ny tantsaha?
iii. Mahomby ve ireo fikambanana na vondron'olona ifotony amin'ny fampihenana ny loza sy fitazomana ny famokarana sy ny velontena eny ambanivohitra?
iv. Inona no fanampina tokony homeny fikambanana na vondronolona ifotony mba hampihena ny loza mahakasika ny famokarana sy ny velontena?

Ny ampiasana ny atonta-kevitra: Ny atonta-kevitra voaangona amin'ity fanadihadiana dia mety hampiasaina aminy fikarohana na fampandrosoana. Ny atontam-kevitra voaangona dia hanampy ny Conservation International (CI) sy ny mpiara miasa any antoerana hijery ireo paikady mahomby mba hoentina miatrika sy mampihena ny loza, ary mijery ireo fikambanana na vondron'olona ifotony izay mety hiarahana miasa amin'ny izany paikady izany.Ity koa dia manome hevitra amin'ny fifidianana ny paikady sy ny fikambanana ifotony izay hampianay CI and ireo mpiara-miombon'antoka ao anatiny Node , mba hanampy ireo tantsaha hiala @ fahosana amin'ny loza. Ny mombamomba manokan'ireo nohadihadiana voangona dia TSY hozaraina aminy fikambanana tsy manao fikarohana; sy ny famintinana ny valim-pikarohana dia homena ireo rehetra nandray anjara tamin'ity fanadihadiana ity, na antsoratra (famoahana boky ny valim-pikarohana) na am-bava amin'ny alalany fivoriana miaraka aminy fikambanana.
Torohevitra ho an'I mpanadihady

1. Lazao ny momba anao sy ny antondianao (araka ny voalaza ao @teny fampidirana)
2. Anotanio tsara raha manana fotoana ny olona ho hadihadiana alohany hireshana. (Raha tsy manana dia maka fotoana hafa Mariho tsara hoe vita daholo ny fanotaniana.
3. Ny valim-panotaniana dia tokony ho hita eo amin'ny faritra misys ny valiny '
4. Jereo fa misys karazany telo ny fanontaniana:
    a. ao @ fanotaniana dia misy '/_/', Vakio tsara ny fanontaniana dia apetaho ny laharany ny valiny (manomboka @ valiny azo hifidianana) mba ahafahana manasokajy ny valim-panotaniana. AZA VAKIANA @ olona hadihadiana ny mety ho valiny
        i. Mariho: Raha manome valiny hafa ankoatry ny hisafidianana izy dia asio ao @ "Hafa" ary asaivo lazainy,
        ii. Azo alaina ohatra ny fanotaniana faha- 2 sy faha3.

b. Amin'ny fanotaniana izay misy malalaka dia vakio tsar any fanotaniana ary fenoy araka izay lazainy olona hadihadiana ny valiny eo @ banga.
   i. Azo atao ohatra ny fanotaniana voalohany sy faha-8.
c. Amin'ny fanontaniana izay mifarana @ teboka roa (' :'), Vakio tsara ny fanotaniana ARY izay mety ho valiny. Mariho izay mifanaraka @ valiny .
   i. Azo atao ohatra ny fanotaniana faha 4 sy 20.

5. MARIHO: NY fomba tsotra mety ahafantarana fa tokony vakina sa tsia ny fanotaniana sy ny mety ho valiny dia jereo ny misy ny baraingo. Raha mifarana @ baraingo ny fanotaniana dia vakio fotsiny ny fanotaniana. Raha ny fanotaniana mifarana @ teboka roa dia ny mety ho valiny mifarana @ baraingo, noho izany dia mila vakiana daholo ny fanotaniana sy ny mety ho valiny.
6. Amin'ny fanotaniana izay manotany hoe Firy (oh: biby, fitaovana) izay ananany , soraty '0' raha tsy manana izy.
7. Mariho: Ny soratra mandry rehetra dia fanazavana ho an'ny mpanadihady ary tsy tokony ho fantatry ny hadihadiana Araho tsar any fanadihadihana.

Fanekena

Ity fanadihadiana ity dia nataony Conservation International hanadiihadiana ny loza mety hitranga @ tantsaha ary ny paik'ady ataony hanalefahany ny fiantraikan' izany loza izany. Izany loza izany dia ireo izay mahakasika ny fambolena, varotra, ny fiovany toetr'andro, ny lalana ary ny loza hafa izay mety hahazo ny tantsaha. Ny fikorahana koa dia liana @ paik'ady ataon'ny lehilahy sy ny vehivavy hiatrehana ny loza. Tsy ambara @ olon-kafa ny andinindinin'ny valinteny avy aminao. Ny antonta-kevitra dia tsy ahitana ny anaranao. Ny valiny nomenao dia tsy hotononina isan'olona. Ny valin'ny fikarohana dia aseho @ ankapobeny ary tsy hisy anaranan'ireo izay namaly ny fanontaniana. Ny fanadihadiana dia natao t@ Novambra and Desambra 2011.

Raha manaiky ianao handray anjara @ ity fanadihadiana ity dia manaova Sonia nap eta-tondro eto ambany. Misaotra anao noho ny fandraisanao anjara @ fanadihadiana.

Sonia
Anarana
Daty.

Mariho eto ny ora nanombohany fanadihadiana:_____ **Mariho eto ny Ora nifaranan'ny fanadihadiana**:_____ **Fitondrana ny fanotaniana:**

	Daty Feno nanaovana ny			Anarana
Asa	Andro	Volana	Taona	
Fanadihadiana				
Fanamarinana eny an-toerana				
Fanamarinana ao amin'ny birao				
Firaketana ny antonta-kevitra				

1. Ny mombamomban ny olona nohadihadiana

Anarany nohadihadiana
1. Lahy sa vavy?
2. Lohan'ny fianakaviana ve ianao? Eny Tsia
3. Raha "tsia" iza no anarany loham-pianakaviana
4. Laharany tokatrano/ N® de ménage:
5. Laharany Fiche d'enquete
6. Anarany olona hafa izay hohadihadiana tao anatiny tokatrano:
7. Inona no nanamboarana ny tafo: 1.Fotaka, 2. Rofia na Bambo na Ravinala, 3.Hazo
8. 4.Biriky sa simenitra, 5. Fanitso, 6 Hafa (Lazao: _____)
9. Inona no nanamboarana ny rindrina: 1.Fotaka, 2. Rofia na Bambo na Ravinala, 3.Hazom 4.Biriky sa simenitra, 5. Fanitso, 6 Hafa (Lazao: _____)

				Maritany ny tanana		
			Code/Marika	**Longitoda**	**Latitoda**	**Haavo**
8	**Tanana**					
9	**Fokontany**					
10	**Kaominina**					
11	**Distrika**					

2. Ny toetrany tokatrano/ caracteristiques de menage:

Fanotaniana sy sivana	**Marika**
12. Oviana ianao no teraka?	*Soraty ny taona nahaterahana*
13. Inona no toeranao ao anaty tokatrano ?	1.Neny/Dada, 2Zanaka vavy/zanaka lahy, 3./Nenitoa /Dadato, 4.Rahavavy/ Rahalahy, 5. zaodahy/zaobavy, 6.Nenibe/ Dadabe, 7. Zanaka mpiray tampo vavy/ Zanaky ny mpiray tampo Lahy, 8.Hafa (Lazao) :
14. Manambady ve ianao?	1. Mpitovo, 2. Manambady ara-dalana, 3.Manambady ara-pomban-drazana, 4.Mananotena, 5.Nilaozambady, 6.Nisara-bady

15. Nanomboka t@ taona lasa: Firy ny isany lahy na vavy mipetraka @ ity tokatrano ity: (soraty ny isany araka ny taona sy ny mahalahy na vavy azy)	1.Zaza < 24volana ? , 2.. 25 volana-12 taona ? 3.13 -18 taona? 4. 19 taona-60 taona? 5. Mihoatra ny 60 taona ? . .
16. Teraka teto ve ianao?	*1.* Eny sa 2 Tsia *Raha eny mifindra @ 20*
17. Firy taona no nipetrahanao teto @ ity Tanana ity ?	1. Latsaky ny 1 taona, 2. 1-5 taona, 3. 6-10 taona, 4. 11-19, 5. Mihoatra ny 20 taona
18. Raha mpifindra monina ianao, taiza no nisy anao taloha?	*(Soraty ny anarany tanana)*
19. Raha mpifindra monina ianao, Inona no antony lehibe nifindranao eto ?	1.Nanambady, 2.Nahazo tany, 3.Nanatsara velontena, 4. Ratsy ny tany taloha 5. Mba hiala olana na tsy filaminana taloha, 6. Mba handrato fianarana tsaratsara kokoa (Sekoly), 7. Nafindrany fanjakana, 8. Hafa (Lazao):_____ (*Fanamarihana : Sorato izay antony GOAVANA nifindrana monina)*
20. Inona no karazana foko misy anao?	*(Soraty ny karazana foko misy azy)*
21. Inona no karazana fivavahana misy anao ?	*1. Protestant, 2. Katolika, 3. Fivavahana nenti-paharazana, 4. Silamo, 5. Tsy misy, 6.Hafa*
22. Inona no fari-pahaizanao?	1. Tsy misy, 2.. Fanabeazana fototra,3. Ambaratonga faharoa fototra, 4.Lycée noho mihoatra
23. Firy @ zanakao no mianatra @? (soraty ny isany zaza isan-tsokajiny) (Soraty aloha ny isany zaza latsaky ny 12 isa-tsokajiny izay mbola mianatra, avy eo ny totaliny zaza latsaky ny 12 taona isa-tsokajiny	*1. Sekoly ao an-tanana, 2. Sekoly any an-tanan-dehibe, 3. Hafa:(Lazao):_____*

3.Toetrany velontena ny tokatrano

24. Hofanao ve ity trano ity sa anao ?	1.Tompon-trano, 2. Mpanofa ,3. Tranom-panjakana,4. *Hafa:(Lazao):_____*
25. Raha anareo ny trano, iza no tompony	1.Raim-pianakaviana,2. Renim-pianakaviana, 3. Samy tompony
26. Inona no jiro ampiasainareo ?	1. Herin'aratra JIRAMA, 2. Groupe electrogene, 3. Pétrole na solika, 4. labozia
27. Inona no hanokonanareo sakafo?	1. Gaza, 2. Pétrole na solika, 3. Saribao, 4. Kitay 5.Hafa(Lazao) : _____ *(Raha '4' no valiny', jereo ny faha 29. Raha tsia,mifindra @ faha32)*
28. Raha kitay no hanokonana sakafo, aiza ianareo no maka kitay: (Eny sa Tsia)	1.Taninareo ihany ? 2.Tanin'nolona mpifanolobodi-rindrina, 3.Tanim-pokonolona ? 4.Ala-pokonolona ? 5. Hafa (Lazao) : _____
29. Adiny firy dia tongotra no maka kitay ? *(Fanamarihana: Allez ihany*)	*1.< 1ora,, 2.* ≥1 - < 2 ora, 3. ≥2 - <4 ora, 4. ≥4 ora
30. Iza no maka kitay ?	1.Vehivavy, 2.Lehilahy,3.Ankizy,4. Ny vehivavy sy ny ankizy, 5.Ny lehilahy sy ny vehivavy ary ny ankizy
31. Aiza ianareo no maka rano fisotro sy handrahoana sakafo rehefa **fahavaratra** ?	1.Mpaompin-dranom-pokonolona,2. Fatsakam-pokonolona, 3. Mpaompin-drano misy tompony,4. Fatsakana misy tompony, 5. Vovo,6. Andrenirano,7. Farihy, matsabory, 8. Hafa (Lazao):_____
32. Aiza ianareo no maka rano rano fisotro sy handrahoana sakafo rehefa maintany?	1.Mpaompin-dranom-pokonolona, 2.Fatsakam-pokonolona, 3.Mpaompin-drano misy tompony, 4.Fatsakana misy tomponyAndrenirano, 5.Vovo, 6.Andrenirano, 7.Farihy, matsabory, 8. Hafa (Lazao):
33. Aiza ianareo no maka rano rano fisotro sy handrahoana sakafo aoriany rivo-doza?	1.Mpaompin-dranom-pokonolona, 2.Fatsakam-pokonolona, 3.Mpaompin-drano misy tompony, 4.Fatsakana misy tomponyAndrenirano, 5.Vovo, 6.Andrenirano, 7.Farihy, matsabory, 8. Hafa (Lazao):
34. Aminy andavanandro, adiny firy ianareo no mahita rano ampiasaina ao antokatrano?	1.< 15 Minitra, 2. ≥15 –- < 0 Minitra, 3. >30 –- -< 60 Minitra, 4. ≥ 1 ora
35. Iza no maka rano ampiasaina ao antokatrano?	1.Lehilahy, 2.Vehivavy, 3.Ankizy, 4.Vehivavy sy ny ankizy, Lehilahy sy ny vehivasy ary ny ankizy

(Apetraka raha misy rezo eo an-tanana dia apetraka ny 36- 37, raha tsy misy dia mifindra @ 38)

36. Manana finday ve ianao sa misy manana ao an-trano?	1. Eny sa 2. Tsia
37. Lavitra ve vao mahazo rezo ny finday?	1. < 15 Minitra, 2) ≥15 –- < 0 Minitra, 3)>30 –- -< 60 Minitra, 4) ≥ 1 ora
38. Fantatrao ve ny M –Vola, Airtel Money, Orange Money?	1. Eny sa 2. Tsia *Raha tsia, mifindra @ 41*
39. Mahazo na misy M –Vola, Airtel Money, Orange Money ve?	1. Eny sa 2.Tsia *(Raha'tsia', mifindra @ faha 41)*
40. Raha eny, adiny firy avy eto antanana vao misy?	*1.* < *1ora,* 2. ≥1-< 2 ora,3. ≥2- <4 ora, 4. ≥4 ora*)*

41. Misy manana kaonty @ banky ve na tahiry ao aminareo?	1. Eny sa 2, Tsia (Raha 'tsia', Mifindra @ fanotaniana faha44)
42. Misoratra @ iza izany tahiry izany?	1.Ny lehilahy ao antokatrano, 2. Ny vehivahy ao antokatrano, 3.Izy roa no miaraka
43. Misy mpikambana @ fikambanana vola-tahiry ve ao anatiny tokatranonareo?	1. Eny 2. Tsia (Raha 'tsia', Mifindra @ fanotaniana faha45)
44. Raha eny, Inona no anaran'ilay fikambanana?	(Soraty ny anarany)
45. Iza @ ireto fitaovam-pamoivoizana ireto no ananareo:	1.Bisikileta ?, 2.Moto ? 3.Fiara ? 4.Tracteur or motoculteur ? 5.Camion ? 6.Sarety? 7.Hafa (Lazao) (Raha tsy misy ny valiny, mifindra @ faha 47)
46. Ao an-tokatranonareo, iza no tompony fitaovam-pamoivoizana raha manana ianareo: (Fanamarihana: Izay ananany ihany apetraka)	1.Bisikileta ?, 2.Moto ? 3.Fiara ? 4.Tracteur or motoculteur ? 5.Camion ? 6.Sarety? 7.Hafa (Lazao) Ny Lahy sa Ny vavy (Raha samy tompony dia mariho lahy' sy 'vavy')

4.Toetrany velontena ny tokatrano

47. Mandritra ny taona, Inona @ireto no fidiram-bola ny tokatrano: Eny sa Tsia *(Mariho izay asa fidiram-bola rehetra na dia kely aza)*	1.Fambolena? 2.Fiompiana ? 3.Jono? 4.Asa tanana? 5.Varotra? 6. Manao Saribo? 7.Mikapa ala? 8. Asa-tselika? Fanamarihana: Asa-tselika raha atao tsindraindray ivelan'ny asa andavanandro)9.Mikarama isambolana? 10.Midrantraka harena an-kibon'ny tany? 11.Hafa, Lazao1.:
48. Ao an-tokatranonareo, inona no zavatra telo tena mampidi-bola mandritra **ny fahavaratra** *Fanamarihana@ hametrahana ny valiny:* *1: Tena manan-danja, 2: Manan-daja faharoa, 3: Manan-danja fahatelo*	*1.Fambolena?2.Fiompiana ?3.Jono?4.Asa tanana?5.Varotra?6.Manao Saribo?7.Mikapa ala?8.Asa-tselika?Fanamarihana: Asa-tselika raha atao tsindraindray ivelan'ny asa andavanandro)9.Mikarama isambolana?10.Midrantraka harena an-kibon'ny tany?11. Hafa(Lazao):*
49. Ao an-tokatranonareo, inona no zavatra telo tena mampidi-bola mandritra ny maintany? Fanamarihana@ hametrahana ny valiny: 1: Tena manan-danja, 2: Manan-daja faharoa 3: Manan-danja fahatelo	*(Ampiasao ireo voalaza tao @ faha 39)* *1.Fambolena?2.Fiompiana ?3.Jono?4.Asa tanana?5.Varotra?6.Manao Saribo?7.Mikapa ala?8.Asa-tselika?Fanamarihana: Asa-tselika raha atao tsindraindray ivelan'ny asa andavanandro)9.Mikarama isambolana?10.Midrantraka harena an-kibon'ny tany?11. Hafa(Lazao):*
50. Ao aminareo, iza @ ireto vokatra ireto no mampidi-bola indrindra @ **Maintany** *(soraty ny anaran'ny vokatra telo voalohany*)	1.Vary, 2. Mangahazo,3. Katsaka, 4.Voanjo, 5. Hafa
51. Firy ny **salan'ny vokatra** azo isan-taona @ ireto vokatra ireto. (*Fanamarihana: Soraty ny totaliny vokatra)*	1.Vary, 2. Mangahazo,3. Katsaka, 4.Voanjo, 5. Hafa
52. Ohatrinona no vidin'ireo any antsena mandritra ny **taom-pamokarana**	1.Vary, 2. Mangahazo,3. Katsaka, 4.Voanjo, 5. Hafa
53. Ohatrinona no vidin'ireo any antsena mandritra ny **Maintso ahitra/ Tsy fiakarany vokatra**	1.Vary, 2. Mangahazo,3. Katsaka, 4.Voanjo, 5. Hafa

54. Firy isan-jato @ ireto vokatra isan-taona no atao sakafo , amidy, ampiriminina Fanamarihana: ampiasao ireto: <25%, 2. .≥25-<50%, 3. ≥50-<75%, 4. ≥75%		Sakafo	Amidy	Sompitra/ Tahiry
	1.Vary, 2. Mangahazo,3. Katsaka, 4.Voanjo, 5. Hafa			
55. Firy isan-jato ny vola miditra no azo @ fambolena mandritra ny fahavaratra?	1.<25%, 2. .≥25-<50%, 3. ≥50-<75%, 4. ≥75%/___/			
56. Firy isan-jato ny vola miditra no azo @ fambolena mandritra **ny maintany**?	1.<25%, 2. .≥25-<50%, 3. ≥50-<75%, 4. ≥75%/___/			

57. AO an-tokatranonareo, iza no manao ireto asa ireto: *(Fanamarihana: Raha tsy mana fidriambola amin'ireo asa ireo ny tokatrano , dia aveloa min'izao)* *Raha mifarimbona manao ny as any ao antokatrano, mariho daholo izay ataony sy hgifarimbonany)*		Lehilahy	Vehivavy	Ankizy	Hafa
	1.Fambolena? 2.Fiompiana ? 3.Jono? 4.Asa tanana? 5.Varotra? 6. Manao Saribo? 7.Mikapa ala? 8. Asa-tselika? Fanamarihana: Asa-	/___/	/___/	/___/	/___/

	tselika raha atao tsindraindray ivelan'ny asa andavanandro)9.Mikar ama isambolana? 10.Midrantraka harena an-kibon'ny tany? 11.Hafa, Lazao1.:				
58. Firy aminareo ao an-trano no miasa any ivelany? (raha '0', mifindra @ fanotaniana faha 61)	*(soraty ny isany)*				
59. Raha misy miasa any ivelany ianareo ao an-trano, dia inona amin'ireto no ataony: 1. Enu 2, Tsia	1.Miasa tanin'olona?2.Miasa @ fikapana hazo (mitatitra)?3.miasa @ fanaovana arina (mpitatitra na mpikapa hazo na mpandoro arina)?4.Miandry ombin'olona?5.Mandroaka ombin'olona hamidy eny an-tsena?6.Miasa @ fitrandrahana harena ankibon'ny tany?7.Miasa @ ozinina?8.Manao vadi-barotra? 9.Hafa (Lazao):				
60. Mandray vola isam-bolana avy any @ havanareo any andrenivohitra ve ianareo?	1. Eny sa 2. Tsia *(Raha'tsia', mifindra @ fanotaniana faha 63)*				
61. Raha eny, ohatrinona isam-bolana?(Apetraho izay nolazainy na fmg na ar)	*(soraty ny vola raisiny isam-bolana) FMG na Ar isam-bolana*				

5.Toetoetran'ny fomba fitantanana ny fambolena

62. Manana ny tanimboly sy tanimbary ve ianareo? (Raha 'tsia', mandehana any amin'ny fanontaniana 66)	1. Eny sa 2. Tsia /___/			
63. Raha manana, ahoana no hazoana azy	1. Tavy @ tanim-panjakana, 2. Nolovaina, 3.Novidiana, 4.Hafa? (lazao): ……			
64. Firy ny velaran'ny tanimbolinao Araka ireto karazany ireto: Tavy, tanimbary hafa, tanimboly hafa	1. < 200m^2, 2. ≥200-<500m^2, 3. ≥500m^2-<1ha 4 .≥ 1- <2 ha, 5. ≥2 ha	Tavy	Tanimbary	Tanimboly hafa
65. Firy ny totalin'ny velaran'ny tany izay volen'ny tokantaranonao ankehitriny (miaraka amin'ny taninao manokana sy ny tany izay hofainao)?	1. < 200m^2, 2. ≥200-<500m^2, 3. ≥500m^2-<1ha, 4 .≥ 1- <2 ha, 5. ≥2 ha	Tavy hatsaky	Tanimbary tsy tavy	Tanimboly hafa
66. Tany misy taratasy ve sa tanim-panjakana ny taninao ?	1. Tany misy titra, 2. Tanim-panjakana 3. Titra sy tanimpanjakana /___/			
67. Manofa tany ve ianao ?	1. Eny, 2.Tsia	/___/		
68. Raha eny, firy ny velaran'ny tanimbary izay tsy tavy na hatsaky hofanao ary firy ny velarany tanimboly hafa hofanao?yFanamarihana:	1. < 200m^2, 2. ≥200-<500m^2, 3. ≥500m^2-<1ha4 .≥ 1- <2 ha, 5. ≥2 ha	Tanimbary fa tsy tavy/hatsaky	Tanimboly hafa	
69. Firy ny isan'ny fizarazarana (na tanimboly) izay volenao ankehitriny (miaraka amin'ny fizarazarana sy tanimboly izay hofainao)?	*(soraty ny totaliny)* *1. Tany sy 2, Tany nofana*			
70. Firy ny totalin'ny velaran'ny tany anao manokana na hofainao, izay TSY volenao ankehitriny (izany hoe, tany mamerimbatana (jachere) na tsy miasa ankehitriny)?	1. < 200m2, 2. ≥200- <500m2, 3. ≥500m2- <1ha 4 .≥ 1- <2 ha, 5. ≥2 ha			
71. Adiny firy ny dianao makany amin'ny tanimbolinao lavitra indrindra ny tranonao?	*1.< 1ora,* 2. ≥1-< 2 ora, 3. ≥2- <4 ora ≥4 ora*)*			
72. Firy isanjaton'ny tany volenao ankehitriny no mamokatra tsara / lonaka	1.Tsy misy , 2. <25%, 3. ≥25-<50%, 3. ≥50-<75%,4. ≥75%			
73. Inona ny teknika fambolena ataonao: Fanamarihana: Asio "eny" izay ampiasainy (Fanamarihana: Asio 'Eny' na di any ampahany @ tany ihany no ampiasany azy)	1.Eny sa 2. Tsia			
74. Inona ny teknika fambolena ataonao: Fanamarihana: Asio "eny" izay ampiasainy (Fanamarihana: Asio 'Eny' na di any ampahany @ tany ihany no ampiasany azy) Manondraka ny volinao ve ianao? Raha tsia, mandehana any amin'ny fanontaniana 78)	1. Mampiaza zezi-pahitra? 2. Mampiaza zezi-bazaha (simika)? 3. Mampiasa masomboly natsaraina? 4. Mampiasa famonoana-biby na fanafody? 4.Mampiasa teknika iarovana ny nofontany (toy ny teknika ampiasaina amin'ny tany avo, na an-tanantohatra, sns)? , 5.Mampiasa voly avotra (izany hoe, mamboly karazam-boly roan a maro miaraka ao amin'ny tanimboly iray)?6.Mampiasa voly mifandimby (rehefa vita ny voly iray oh vary dia asiana tsaramaso indray avy eo,.7. Manao ala vadim-boly?8. Manao tavy/ hatsaky anadiovana ny tanimboly?			
75. Inona ny fomba fanondrahana ampiasainao?	1.Manondraka @ arozoara, 2. Mampiasa paompy ,3..Mampiasa paompy mandeha @ herimbaratra,4. Fitarihan-drano iombonana,5. Hafa (lazao……../			
76. Inona ny voly tondrahanao?	*Tanisao ny anaran'ny voly REHETRA izay tondrahanao*			

77.	Volana inona ianao no manondraka?	*Tanisao ireo volana fanondrahan'ny mpamboly*
78.	Inona amin'ireto voly manaraka ireto, raha misy, no nambolen'ny tokantranonao nandritry tamin'ny taom-pambolena tamin'ny taona lasa:	*1.Vary? 2. Katsaka? 3.Mangahazo? 4.Kafe? 5.Soanambo? 6.Akondro? 7.Voanjo? 8.Letisi? 9.Sakamalao? 10.Tsaramaso? 11. Pitipoa?12.Manga? 13.Voasary? 14.Fary? 15.Saonjo?16.Ovy?17. Vomanga/ Batata? 18. Hafa (lazao)*
79.	Inona amin'ireto voly ireto no vokarinao ho an'ny filàna ao an-tokantrano ary inona no amidinao: (fanamarihana: raha tsy mamboly amin'ireo voly voatanisa izy ireo, avelao ho banga. Raha sady ampiasainy amin'ny filàna ao an-tokantrano no sady amidiny, dia mariho ny faritra roa)	*1.Vary? 2. Katsaka? 3.Mangahazo? 4.Kafe? 5.Soanambo? 6.Akondro? 7.Voanjo? 8.Letisi? 9.Sakamalao? 10.Tsaramaso? 11. Pitipoa?12.Manga? 13.Voasary? 14.Fary? 15.Saonjo?16.Ovy?17. Vomanga/ Batata? 18. Hafa (lazao)*
80.	Amin'ireto voly ireo, inona no tena ilain'ny tokantranonao amin'ny sakafo mandritry ny Fahavaratra?	*(ampiasao ny lisitra nampiasaina tamin'ny fanontaniana 79) 1. manan-danja indrindra , 2. manan-danja faharoa, 3. manan-danja fahatelo*
81.	Amin'ireto voly ireto, inona no telo tena ilain'ny tokantranonao atao sakafo mandritry ny maintany?	*(ampiasao ny lisitra nampiasaina tamin'ny fanontaniana 79 1. manan-danja indrindra , 2. manan-danja faharoa, 3. manan-danja fahatelo*
82.	Amin'ireto voly ireto, iza telo tena manan-danja indrindra amin'ny fidirambolan'ny tokantranonao ?	*(ampiasao ny lisitra nampiasaina tamin'ny fanontaniana 79 1. manan-danja indrindra , 2. manan-danja faharoa, 3. manan-danja fahatelo*
83.	Ao an-tokantranonao, iza no manao ireto asa-pambolena manaraka ireto : (Fanamarihana: raha ny lahy sy ny vavy no miaraka tompon'andraikitra amin'io asa io, mariho ny faritra roa) Ny lahy sa Ny Vavy	*1.Manapakevitra @ voly atao, 2. Mividy masomboly, 3. Manomana ny tany hambolena ?4.Mamboly, 5.manisy zezika ?6.Miava ?7. Manangombokatra ?8.Mioty ny voa ?9.Mampirina ny voa ?10. Mitondra any an-tsena ?11.Mivarotra*
84.	Amin'ny ankapobeny, aiza no itahirizanao ny vokatrao?	*1.Ao an-trano , 2.Ao anaty sopitra iraisana na amin'ny vondron'olona na hofaina Hafa (lazao) _____*
85.	Amin'ny ankapobeny, mahavita taona ve ny vary vokatrao?	*1. Eny 2. Tsia (Raha tsia ny valiny, mandehana any amin'ny fanontaniana 88)*
86.	Raha tsia, isaky ny volana inona no fantatrao fa tsy ampy ny vary ao an-tokantranonao?	*Tanisao ireo volana*
87.	Raha tsy ampy ho an'ny tokantranonao ny vary vokarinao avy amin'ny taninao manokana ao mandritra ny taona iray, inona amin'ireto fomba ireo no ianteheranao:	*1.Ahena ny fandaniana amin'ny sakafo hanina andavanandro (fatra sy atetin'ny sakafo) ? 2.Mioty vokatra dia ? 3. Mividy fanampian-tsakafo? 4. Mahazo sakafo avy amin'ny mpifanolobodirindrina 5.Mahazo sakafo avy amin'ny havana ?6.Mahazo sakafo avy amin'ny fikambanana tsy miankina na miankina amin'ny Fanjakana? 7.Hafa (lazao)*
88.	Iza @ ireto vokatra ireto no otazanao @ ankapobeny?	*1.Tsy mioty vokatra dia , 2.Ovyala , 3.Lambo, 4.Gidro, 5.Sahona, 6.Tavolo/Kabija, 7.Vorona, 8.Bibilava, 9.Hafa*
89.	Inona @ ireo vokatra dia ireo no tena ilainy tokatranonao @ maintso ahitra?	*Tanisao daholo*
90.	Raha mioty vokatra ny tokantranonao mandritry ny maitsoahitra, afiriana no laninao mankany ahazoana izany izany?	*1.< 1ora, 2.≥1-< 2 ora, 3.≥2- <4 ora, 4.≥4 ora)*
91.	Firy amin'ireto biby manaraka ireto (raha misy) no ananan'ny tokantranonao : Isan'ny biby (raha tsy misy dia asio "0")	*1.Omby? 2.Osy? 3.Ondry? 4.Kisoa? 5.Akoho? 6.Gana? 7.Biby hafa (lazao) : __(Raha tsy manana biby fiompy dia mandehana any amin'ny fanontaniana 95)*
92.	Ao an-tokantranonao, iza no manana iretro biby manaraka ireto: Ny Lahy sa Ny vavy (Raha lahy sy vavy miaraka dia mariho lahy sy vavy miaraka) (Fanamarihana: izay biby ananan'izy ireo ihany no marihina. Raha tsy manana izy ireo dia avelao ho banga)	*1.Omby? 2.Osy? 3.Ondry? 4.Kisoa? 5.Akoho? 6.Gana? 7.Biby hafa (lazao)*
93.	Raha manana biby fiompy ny tokantranonao, iza no miandraikitra ireto asa manaraka ireto: *(Fanamarihana: mariho izay izy. Raha izy rehetra no manao ny asa dia mariho daholo. Raha tsy manana asa manokana izy ireo, avelao ho banga)* (	

	Lahy Vavy Ankizy mpiasa
1.Mikarakar akoho na gisa ?	/___/ /___/ /___//___/
2. Miandry omby?	/___/ /___/ /___//___/
3. Mitery rononon'omby	/___/ /___/ /___//___/
4. Mitondra ny omby na biby fiompy hafa amidy any an-tsena?	/___/ /___/ /___//___/
5. Mivarotra ny omby na biby fiompy hafa any an-tsena?	/___/ /___/ /___//___/

94. Raha manana biby fiompy ny tokantranonao, inona amin'ireto no ataony sakafo na amidy:	1. Hena ?	Sakafo	Amidy	Izy roa
	2. Ronono ?	/___/	/___/	/___/
	3. Atody?	/___/	/___/	/___/
	4. Hoditra na tandroka ?	/___/	/___/	/___/
95. Miompy trondro na manjono ve ny ao @ nareo?	1. Eny. Miompy trondro, 2.Tsia , tsy miompy,3. Eny , manjono eny @ renirano na farihy na eny @ ranomasina, 4. Tsy manjono *(raha tsia, mandehana any amin'ny fanontaniana 98)*/___/			

96. Raha eny, amidy ve sa atao sakafo ny trondro azonareo ?	1. Atao sakafo ao an- tokantranonao ihany , 2. Amidy ihany ,3. Sady hohanina no hamidy /___/
97. Ahoana ny fomba fitaterana vokatra mankany an-tsena?	1. Mandeha an-tongotra , 2.Sarety,3. Bisikileta,4. Fiara ,5. Fiara mpitatitra iombonana ,6.Hafa (lazao) /___/
98. adiny firy no makany an-tsena akaiky indrindra ahafahanao mividy vokatra?	*1.< 1ora, 2.* ≥1-< 2 ora, 3. ≥2- <4 ora ≥4 ora)/___/
99. Nahazo fanampiana teknika momban'ny famokarana vokatra na fiompiana avy amin'ny fikambanana ve ianao?	Eny sa 2 Tsia *(Raha tsia, mandehana any amin'ny fanontaniana #102)* /___/
100. Raha eny, iza no anarany (na anaran'ireo) fikambanana nanome fanampiana ara-teknika famokarana anao ?	*(Soraty ny anaran'ny fikambanana)* ***Raha tsy fantany dia soarty hoe "tsy fantany"***
101. Aiza ianareo no mahary vaovao momba ny vidin'entana	*1. Avy namana tantsaha, 2.Avy @ fikambanana, 3. Avy @ Radio, 4. Eny an-tsena*

6.**Olana eo amin'ny vokatra sy nyvelotena ambanivohitra, ahoana no iatrehan'ireo tantsaka ireo olana ireo, ary iza ny fikambanana manome azy ireo fanampiana**

102. Tanatin'ny 5 taona lasa, inona amin'ireto olana voatanisa ireto no nisedrain'ny **tanimbarinao sy ny varinao**: *Fanamarihna : Raha tsy mamboly vary dia mifindra @ fanontaniana 105* Eny sa Tsia	1.Aretina mahery? 2. Fahasimbany voly vokatry ny bibikely, lambo, voalavo, valala? 3.Fahasimbam-bokatra lehibe mandritry ny fanamainana azy sy mandritra ny fitahirizana ao an-tsopitra? 4.Nihena ny vokatra noho ny rotsakorana kely loatra? 5.Nihena ny vokatra noho ny rotsakorana be loatra? Eny Tsia
103. Raha eny, impiry no nisedran'ny tanimbolinao ny tsirairay amin'ireo olana ireo tanatin'ny 5 taona lasa? (*Raha mbola tsy tratran'reo loza ireo dia avelao ho banga fotsiny*)	1. Aretina mahery, 2. Fahasimbany voly vokatry ny bibikely, lambo, voalavo, valala? 3. Fahasimbam-bokatra lehibe mandritry fanamainana azy sy mandritra ny ny fitahirizana? 4 .Nihena ny vokatra noho ny rotsak'orana vitsy loatra? 5.Nihena ny vokatra noho ny rotsak'orana be loatra?
104. T@ taona lasa, firy isan-jaton'ny **voka-barinao** no simba nohon'ny aretina na bibikely?	a)<10%. b)≥10% - <25% c) ≥25- < 50%d) ≥50% /___/
105. Amin'ny ankapobeny, firy isan-jaton'ny **voka-barinao** no simba tao an-tsopitra noho ny bibikely na voalavo na tratran'ny fahalovana.	a)<10%. b)≥10% - <25% c) ≥25- < 50%d) ≥50% /___/
106. Nandritry ny 5 taona lasa, nanana tanim--katsaka/mangahazo sy ny vokatra nisedra ireto olana manaraka ireto ve ianao? (Fanamarihana: Anotanio izay vokatra manandanja faharoa ary soraty eo ambany alohan'ny hametrahana fanontaniana. Soraty hoa Katsaka na mangahazo na voly hafa , lazao ny anarany):	Eny sa Tsia 1.Aretina mahery? 2. Fahasimbany voly vokatry ny bibikely, lambo, voalavo, valala?? 3.Fahasimbam-bokatra lehibe mandritry fanamainana azy sy mandritra ny ny fitahirizana? 4. Nihena noho ny rotsak'orana vitsy loatra? 5.Nihena noho ny rotsak'orana be loatra?

107. Raha eny, impiry ny katsaka/mangahazo sy ny vokatra no nisedra ny tsirairay amin'ireto olana ireto nandritry ny 5 taona lasa? (Fanamarihana : ireo voly voalaza tao @ 107)	Impiry tao anatiny 5 taona lasa 1.Aretina mahery? 2. Fahasimbany voly vokatry ny bibikely, lambo, voalavo, valala?? 3.Fahasimbam-bokatra lehibe mandritry fanamainana azy sy mandritra ny ny fitahirizana? 4. Nihena noho ny rotsak'orana vitsy loatra? 5.Nihena noho ny rotsak'orana be loatra?
108. Amin'ny taona iray manokana, firy isan-jato ny vokatra **katsaka/mangahazo** no very noho ny aretina na fahavalom-bokatra? (*Fanamarihana : ireo voly voalaza tao @ 107)*	a)<10%. b)≥10% - <25% c) ≥25- < 50%d) ≥50% /___/
109. Amin'ny taona iray manokana, firy isan-jaton'ny vokatra **katsaka/mangahazo** no simba tao an-tsopitra noho ny bibikely na voalavo na tratran'ny fahalovana (*Fanamarihana : ireo voly voalaza tao @ 107*	a)<10%. b)≥10% - <25% c) ≥25- < 50%d) ≥50% /___/
110. Raha simba noho ny aretina na fahavalom-boly ny vokatrao, mbola ampy ve ny sakafon'ny ankohonanao	1.Eny sa 2. Tsia Raha 'eny' mifindra @ 112
111. Raha 'tsia' firy volana tsy ampy ny sakafo	Lazao ny isan'ny volana
112. Raha simba noho ny aretina na fahavalom-boly ny vokatrao	a.Tsy nisy , b. <25% ny fihenany c. ≥25- <50% ny fihenany, d.≥50-<75% ny fihenany,e. >75% ny fihenany

113. Amin'ireo karazana fanampiana azonao taorian'ny **rivodoza**, inona no tena nilain'ny tokantranonao indrindra? Lazao jereo ny valiny fanontanina109, raha tsy nisy fiantraikany tondradrano tanatiny 5 taona dia mifindra 146	*1.Fanampiana ara-tsakafo? 2.Fampindramana na fampisamboram-bola? 3.Fahazona vola vonjy taitra? 4.Fanampiana miaraka amin'ny fifindra-trano na fifindra-monina? 5.Fanampiana tamin'ny fitaovana nanamboarana trano? 6. Fitaovana ilaina amin'ny fiompiana? 7.Fanampiana amin'ny fiompiana (masomboly, zezika, sns.) mba amelomana indray ny voly? 8.Hafa lazao*
114. Nandritry ny tondra-drano farany teo, hatraiza ny fahasimban'ny tranonao?	1.Tsy simba , 2. Simba kely, 3. Simba antonontonony , 4. Simba be (nilana fanamboarana) /___/
115. Nandritry ny tondra-drano farany, firy isanjato (raha nisy) tamin'ny vokatrao no simba?	1.Tsy nisy , 2. <25% no simba , 3. ≥25- <50% no simba 4. ≥50-<75% no sImba, 5. ≥75% no sImba /___/
116. Taorian'ny tondra-drano nahery indrindra farany, ampy ho an'ny tokantranonao ve ny sakafo nohaniny?	1. Eny 2Tsia *(raha tsia, mandehana any amin'ny #140)* /___/
117. Raha 'tsia', firy volana no tsy ampy ny sakafo nohanina tao an-tokantranonao?	(soraty ny isan'ny volana) /___/ volana
118. Taorian'ny tondra-drano mahery farany teo, ohatrinona no nihena tamin'ny fidirambolanao	a.Tsy nisy , b. <25% ny fihenany, c. ≥25- <50% ny fihenany ,d. ≥50-<75% ny fihenany, e. ≥75% ny fihenany /___/
119. A Taorian'ny tondra-drano mahery farany, nitady fanampiana tamin'olona na fikambanana na ve ianao?	1. Eny 2. Tsia *(raha 'tsia', mandehana any amin'ny fanontaniana #143)* /___/
120. Raha eny, iza no olona na fikambanana nanampy anao? Eny Tsia	*1.Mpifanolobodi-rindrina/ mpianamana, 2. Ny Havana, 3. Fikambanana ifotony (lazao ny anarany), 4. Fikambanana mpanampy (lazao ny anarany)*
121. Inona amin'ireo karazana fanampiana, raha nisy, no azonao tamin'ny fikambanana taorian'ny tondradrano?	*1.Fanampiana ara-tsakafo? 2. 2. Fanampiana ara-teknika momban'ny fambolena? 3. Fanampiana @ fitaritana rano mba ampihena ny tondradrano manaraka?4. Fahazona vola vonjy taitra? 5. Fanampiana miaraka amin'ny fifindra-trano na fifindra-monina? 6. Fanampiana tamin'ny fitaovana nanamboarana trano? 7. Hafa (lazao)*
122. Amin'ireo karazana fanampiana azonao taorian'ny tondra-drano, inona no tena nilain'ny tokantranonao indrindra iatrehany ny vokatry ny tondradrano?	*(ampiasao ny lisitra tamin'ny #142)*
123. Niova ve ny fomba fambolenao taorian'ny tondra-drano?	1.Eny 2.Tsia *(raha 'tsia', mandehana any amin'ny fanontaniana #148)*
124. Inona (raha msiy) amin'ny fiovana no nataonao taorian'ny tondradrano? Eny Tsia	1.Nanova voly ? 2.Nanova karazam-boly3.Namboly indray taorian'ny tondradrano? 4.Nanao tatatra mba ialan'ny rano avy tao an-tanimboly? 5.Nanova faharetan'ny

	fambolena voly? 6. Naato ny famokarana teo amin'ny tany tratran'ny tondradrano? 7.Hafa (Lazao)
125. Manao ahoana ny fahombiazan'ireo fanovana fomba ireo mba ampihena ny arefonao anoloan'ny tondradrano manaraka?	1.Tsy nahomby , 2.Antonony ny fahombiazana , 3.Mahomby amin'ny akapobeny , 4.Tena mahomby

Fanamarihana: jereo ny valiny fanontanina 121, raha tsy nisy fiantraikany haintany tanatiny 5 taona dia mifindra 157b

126. Raha tojo na nisedra aretina na fahavalom-bokatra na olana ara-fitahirizana ny vokatrao, nitady fanampiana ara-teknika ve ianao?	a) Eny b) Tsia *(raha tsia, mandehana any amin'ny fanontaniana #116)*
127. Raha 'eny', iza no manome fanampiana anao amin'ny teknika famokarana? (Fanamarihana: Raha tsy 3 na 4 no valiny dia mifindra @ 116)	1.Mpifanolobodi-rindrina/ mpianamana, 2.Ny Havana, 3.Fikambanana ifotony (lazao ny anarany),4. Fikambanana mpanampy (lazao ny anarany)
128. Raha nahazo fanampiana avy @ fikambanana ianao. ahoana no fiantraikan'reo fanampiana ara-teknika ireo @ fomba famokaranao?	1.Tsy mahomby, 2. Eo ho eo ihany ny fahombiazany, 3. Mahomby amin'ny akapobeny, 4. Tena mahomby

129. Tao anatiny 5 taona lasa, efa nisy very ve na maty ny ombinao noho ireto antony ireto?	1.Aretina na areti-mifindra? 2.Halatr'omby?3.Haintany, 4.3. Hafa (Fanamarihana: Raha "tsia" ny valin'ny fanontaniana rehetra, mandehana any amin'ny 118)
130. Raha eny, firy ny totalin'ny biby very avy amin'ireto olana tanisaina manaraka ireto nandritry ny 5 taona:	Lazao ny isan'ny very tanatin'ny 5 taona lasa noho ny: 1.Aretina na areti-mifindra? 2.Halatr'omby3.Haintany4.Hafa
131. Rahefa tojo fahasahiranana ny fiompinao, mitady fanampiana ara-teknika @ olona na fikambanana ve ianao?	1.Eny 2. Tsia *(Fanamarihana: Raha 'tsia' mifindra @ 120)*
132. Raha eny, iza no manome fanampiana anao amin'ny fiompiana? Eny sa Tsia	1.Mpifanolobodi-rindrina/ mpianamana, 2.Ny Havana, 3.Fikambanana ifotony (lazao ny anarany), Fikambanana mpanampy (lazao ny anarany)
133. Raha nahazo fanampiana avy @ fikambanana ianao. ahoana no fiantraikan'reo fanampiana ara-teknika ireo @ ny fiompianao?	1.Tsy mahomby , 2.Eo ho eo ihany ny fahombiazan, 3. Mahomby amin'ny akapobeny , 4.Tena mahomby
134. Tao anatin'ny 5 taona, nisedra olana avy amin'ireto tranga ireto ve ny tokantranonao?	1. Rivodoza? 2. Tondra-drano mahery? 3. Haintany mahery? 4. Doro-tanety tsy voahambina, .(raha tsia @ izy rehetra, mandehana any amin'ny fanontaniana 157)
135. Raha eny, impiry ny tokantranonao no tojo ireo tranga ireo nandritry ny 5 taona lasa? Lazao ny isan'ny tranga; raha tsy misy dia soraty '0')	1. Rivodoza? 2. Tondra-drano mahery? 3. Haintany mahery? 4. Doro-tanety tsy voahambina,
136. Nadritry ny rivodoza nahery indrindra farany teo, firy amin'ny ankohonano, raha nisy, no naratra na maty?	*(Soraty ny isan'ny olona, raha tsy misy dia asio "0")Firy no tena naratra mafy , Firy no no maty(*
137. Nandritry ny rivodoza nahery indrindra farany teo, hatraiza ny fahasimban'ny tranonao?	1Tsy simba , 2. Simba ny tafo,3. Simba ny tafo sy ny rindrina, 4. Rava tanteraka ny trano 5,.Raha '1' no valiny dia mifindra @ 127
138. Namboarina ve ny tafonao na ny rindrinao tamin'ny rivodoza farany teo?	1. Eny sa 2. Tsia *(raha 'tsia', mandehana any amin'ny #127)*
139. Raha izany, afiriana no nandehananao tongotra ahazoanao fitaovana nanamboarana ny tafonao sy ny rindrinao? Fanamarihana: Izay ora lavitra indrindra no apetraka @ fitadiavana fitovana (Oh: Hazo no lavitra indrindra fa ny fasika akaiky dia ny halavirany fakana hazo no apetraka)	a. <<1ora, b.≥1 ora <2ora , c. ≥2- <4 ora, d. ≥4 ora
140. Taorian'ny rivodoza nahery indrindra farany teo, ohatrinona no nihena tamin'ny fidirambolanao	a.Tsy nisy , b. <25% ny fihenany c. ≥25- <50% ny fihenany, d. ≥50-<75% ny fihenany, e. >75% ny fihenany
141. Nandritry ny rivodoza nahery indrindra farany, firy isanjato (raha nisy) tamin'ny vokatrao no simba?	a.Tsy nisy , b. <25% ny simba c. ≥25- <50% ny simba, d. ≥50-<75% ny simba, e. >75% ny simba
142. Taorian'ny rivodoza nahery indrindra farany teo, niova ve ny fahafahana mahazo sakafo dia?	1.Tsy niova , 2. Eny, Nihena ny fahafahana mahazo sakafo dia , 3. Eny, Nitombo ny fahafahana mahazo sakafo dia
143. Taorian'ny rivodoza nahery indrindra farany, ampy ho an'ny ankohonanao ve ny sakafo nohaniny?	1.Eny 2. Tsia *(raha tsia, mandehana any amin'ny #132)*
144. Raha 'tsia', firy volana no tsy ampy ny sakafo nohanina tao an-tokantranonao?	*(soraty ny isan'ny volana taorian'ny rivodoza ka tsy nahampian'ny sakafo tao an-tokantranonao)*
145. Taorian'ny **rivodoza nahery indrindra** farany, iza (raha nisy) amin'ireto no nitadiavan'ny tokantranonao fanampiana?	*1.Mpifanolobodi-rindrina/ namana, 2. Ny Havana, 3. Fikambanana ifotony (lazao ny anarany), 4. Fikambanana mpanampy (lazao ny anarany)*
146. Iza amin'ireto karazam-panampiana ireto, raha nisy, no azon'ny tokantranonao avy amin'ny **fikambanana** (**na vondronolona**) taorian'ny rivodoza farany ? Eny sa Tsia	1. Fanampiana ara-tsakafo? 2.Fampindramana na fampisamboram-bola? 3.Fahazona vola vonjy taitra? 4.Fanampiana miaraka amin'ny fifindra-trano na fifindra-monina? 5.Fanampiana tamin'ny fitaovana nanamboarana trano? 6.Fitaovana ilaina amin'ny fiompiana? 7.Fanampiana amin'ny fiompiana (masomboly, zezika, sns.) mba amelomana indray ny voly? 8.Hafa lazao

Fanamarihana: jereo ny valiny fanontanina 121, raha tsy nisy fiantraikany haintany tanatiny 5 taona dia mifindra 157 b

147. Nandritry ny haintany mahery farany, firy isan-jato (raha nisy) ny volinao simba?	1.Tsy nisy, 2. <25% no simba ,3. ≥25- <50% no simba ,4.≥50-<75% no sImba,5. ≥75% no sImba /___/
148. Taorian'ny **haintany** mahery farany teo, ohatrinona no nihena tamin'ny fidiram-bolanao	1,Tsy nisy ,2. <25% ny fihenany,3. ≥25- <50% ny fihenany, 4. ≥50-<75% ny fihenany, 5. ≥75% ny fihenany /___/
149. Nandritry ny haintany mahery farany, afiriana no noana ny ankohonanao?	/___/ volana
150. Taorian'ny haintany mahery farany, nitady fanampiana tamin'olona na fikambanana ve ianao? Eny sa. Tsia (raha tsi, mandehana any amin'ny #154)	1.Mpifanolobodi-rindrina/ namana, 2.Ny Havana, 3.Fikambanana ifotony (lazao ny anarany), 4.Fikambanana mpanampy (lazao ny anarany)
151. Raha izany, iza no nitadiavana fanampiana?	Eny Tsia

152. Inona amin'ireo karazana fanampiana, raha nisy, no azonao tamin'ny **fikambanana** taorian'ny **haintany**? Eny sa Tsia	*1.Fanampiana ara-tsakafo? 2.Fanampiana momban'ny famatsiana rano sy/na fanondrahana?3.Fampindramana na fisamboram-bola?4.Fahazoana vola vonjy taitra?5.Fanampiana ara-fifindrana toerana na fifindramonina? 6.Hafa (Lazao)*
153. Amin'ireo karazana fanampiana azonao taorian'ny **haintany** mahery, inona no tena nilain'ny tokantranonao indrindra iatrehany ny vokatry ny tondradrano?	*(Ampiasao ny lisitra mitovy amin'ny 152) /___/*
154. Nandritry ny haintany mahery farany, nisy niova ve ny fomba famokaranao?	1. Eny 2.Tsia *(raha 'tsia', mandehana any amin'ny #157) /___/*
155. Inona (raha nisy) amin'ny ireto fiovana iretono nataonao taorian'ny haintany? Eny Tsia 156.	1.Nanova karazana voly? 2.Nanova fomba fambolena? 3.Niova ny fotoana fambolena? 4. Niova toerana nambolena? 5. Nanorina fomba fanangonana vokatra? 6. Nanorina fomba fanondrahana ? 7. Hafa (Lazao)
157. Raha ny hevitrao, ahoana ny fahombiazan'ireo fanovana ireo mba hampihena ny arefon'ny vokatrao miatrika ny haintany manaraka?	1.Tsy mahomby, 2. Mahomby eo amin'ny antonony , 3. Mahomby amin'ny akapobeny , 4. Tena mahomby
158. Hatrizay tsy nahampian'ny vokatrao (noho ny antony aretina, na fahavalom-bokatra na toetrandro) araky ny filan'ny ankohonanao, inona amin'ireto fepetra ireo (raha nisy) no noraisin'ny tokantranonao nanatanterahana ny filany: (Fanamarihana: raha 6, 7, ary 8 no valiny dia mifindra 160)	1.Nahena ny sakafo nohanina? 2. Nahena ny isan'ny sakafo isan'andro? 3.Nampitomboina ny sakafo novidiana tany an-tsena? 4.Niova ny karazana sakafo? 5. Nampitombo sakafo azo avy amin'ny zavamaniry na biby dia? 6.Nahazo sakafo avy amin'ny Havana? 7.Nahazo sakafo avy amin'ny mpiray void-rindrina na mpikambana amin'ny vondronolona? 8.Nahazo fanampiana ara-tsakafo avy amin'ny fikambanana? 9.Nindrana/ nitrosa sakafo @ mpifanolobodi-rindrina, 2.Hafa (lazao)
159. Raha mahazo fanampiana ara-tsakafo hatrizay tsy fahampian'ny vokatra tamin'ny filan'ny tokantranonao, iza no olona na fikambanana nahazoanao fanampiana?	*1.Mpifanolobodi-rindrina/ namanaNy Havana, 2. Fikambanana ifotony (lazao ny anarany), 3. Fikambanana mpanampy (lazao ny anarany)* Eny Tsia
160. Hatrizay, raha kely ny vokatra noho ny aretina, fahavalom-bokatra na andro ratsy, inona no fepetra noraisinao mba ampihena ny lany tamin'ny tokantranonao? Eny Tsia	*1.Naato tsy nianatra ny ankizilahy? 2.Naato tsy nianatra ny ankizivavy? 3.Nampitombona ny asa fanaon'ny ankizy? 4.Nalefa niasa ny ankizy lehibe? 5.Nalefa niasa ivelan'ny tokantrano ny zatovo iray? 6.Nomena tantsaha ny tany?*
161. Hatramizay, raha ratsy be ny vokatra noho ny aretina, fahavalom-bokatra na andro ratsy, nisy tao amin'ny ankohonanao ve nitady asa tany ivelany na nifindra monina tany an-toerankafa?	1. Eny 2. Tsia
162. Hatramizay, raha nihena be noho loza ny vokatrao, nivarotra entana mba hanampiana ny vola hividianana sakafo sy filana hafa ve ianao?	1.Eny sa 2. Tsia *(raha 'tsia', mandehana azafady any amin'ny fanontaniana #165)*
163. Raha eny, inona amin'ireto entana ireto, raha nisy, no namidinao? Eny Tsia	1.Biby fiompy? 2.Fitaovana ara-pambolena sy fiompiana? 3.Trano? 4.Tany?5.Finday? 6.Fiara iray?7.Hafa (lazao):
164. Iza no nanapa-kevitra ny hivarotra?	1.Lehilahy ao amin'ny tokantrano, 2. Vehivavy ao amin'ny tokantrano, 3. Niraisanan'ny lahy sy ny vavy tao amin'ny tokantrano, 4.Hafa (lazao) ____
165. Nisy fotoana taloha ve naharatsy ny vokatra na tsy nety mihitsy ka nahatonga anareo nindram-bola	1.Eny 2.Tsia*(Raha 'tsia' mifindra faha, 170)*/___/
166. Raha eny, aiza ianareo no mindram-bola	1.Havana, 2. Mpifanolo-bodirindrana,3. mpampindram-bola, 4. Fikambanana, 5. Fiangonana, 6. Mpikarakara ny fambolena, 6. Banky, 7. International NGO, 8. Orin'asa mpampindram-bola, 9. Fikambanany tantsaha, 10.Hafa lazao----------
167. Iza no fikambanana na orin'asa nindramanareo vola tao anatiny 5 taona	*Soraty ny anarany (soraty 'tsisy', raha tsy mbola nindrana ry zareo*
168. Ao an-tokantrano, iza no manapa-kevitra @ fisamboram-bola	1.Lehilahy, 2. Vehivavy, 3. Izy roa /___/
169. Ao an-trano, iza no tokony ahazo fisamboram-bola	1.Lehilahy, 2. Vehivavy, 3. Izy roa /___/
170. Tao anatiny 5 taona, iza @ ireto olana ara-barotra ireto raha nisy : Eny Tsia	1.Miovaova be ny vidim-bokatra? 2.Ambany ny vidim-bokatra? 3.Tsy lafo ny vokatra satria tsy misy manontany? 4.Tsy lafo ny vokatra satria tsy misy lalana? 5.Lafo ireo zavatra ilaina @ fambolena (zezika, masomboly,fanafody)?

171. Raha misy olana @ famoaham-bokatra, misy fikamnbanana ve manampy anareo	1.Eny sa 2. Tsia *(Raha 'tsia' mifindra faha 174)* /___/
172. Raha eny, iza no fikambanana manampy anareo @ lalam-barotra	(*Lazao ny anarany fikambanana)*
173. Inona @ ireto fanampiana ireto raha nisy no azonareo t@ fikambanana	1.Lalam-barotra? 2.Fitadiavana lalam-barotra? 3.Findramam-bola ho an'I fambolena 4.Fampitaovana tsy vidina momba ny famokarana
174. Efa niisy fotoana ve nahazoanareo ireto fanampiana ireto	1. Fanampiana @ teknika famokarana? 2.Fampitaovana (e.g., masomboly, zezika)? 3.Fanaovana toha-drano? 4. lalam-Barotra 5. Fiofanana, 6. fanampiana ara-=tsakafo? 7. fampindramam-bola? 8. Fanaovana tahirim-bola? 9. Mahazo vola na vonji-taitra, 10 . Fanampiana @ fifindra-monina? 11. Fanamboarana trano samba noho ny loza voajanahary na tundra-drano?12 . Fampitaovana? 13. Hafa lazao
175. inona @ ireto fanampiana avy @ fikambanana ireto no ilainao raha nisy rivo-doza , tondra-drano mahery na haintany mahery:	1.Fanampiana @ teknika famokarana? 2.Fampitaovana (e.g., masomboly, zezika)? 3. Fanaovana toha-drano? 4.Fitadiavana lalam-Barotra? 5.Fiofanana? 6.Fanampiana ara-tsakafo? 7. Fampindramam-bola? 7. Mahazo vola na vonji-taitra? 8. Fanampiana @ fifindra-monina? 9. Fanamboarana trano samba noho ny loza voajanahary na tundra-drano? 10. Fampitaovana? 11. Fanampiana avy @ mpiara-monina? 12. Hafa lazao
176. Inona no fanampiana eritreretinao hoentina miady @ loza voajanahary (tondra-drano, rivo-doza, haintany) (Soraty daholo izay lazainy)	

7.**Fiovana tsapa @ loza mikasika ny famokarana (izay misy ifandraisany @ toetr'andro)**

Niova ve ny voka –bary tao anatiny 10 taona?	1. Eny 2. Tsia *Raha tsia mifindra faha '#180)*
Raha eny, niakatra ve ny voka-bary sa nihena?	1.Niakatra ny vokatra, 2. Tsy niova, 3. Nihena /___/
T@ taona firy no be ny voka-bary taty?	*Omeo ny taona (oh., 2007)*/___/
Niova ve ny toetr'andro tao anatiny 10 taona ?	1. Eny 2. Tsia Raha tsia mifindra faha '#197) /___/
Inona @ ireto fiovana ireto no hitanao tao anatiny folo taona: Eny Tsia	1.Niha nafana ny andro ? 2. Niha mangatsiaka ny andro ? 3. Be ny orana ? 4.Kely ny orana ? 5. Miovaova ny latsak'orana ? 6. Tsy miovaova ny latsak'orana ? 7. Be ny rivo-doza ? 8. Visty ny rivo-doza ? 9. Mahery ny rivo-doza ? 10. Malemy ny rivo-doza? 11. Miovaova ny toetra'andro ? 12. Hafa lazao) ;
Novanao ve ny fomba fambolenao noho ny fiovaovany toetr'andro tao anatiny folo taona lasa?	1. Eny 2.Tsia *(Raha tsia, mifindra faha 185)* /___/
Novanao ve ny karazam-boly, noho ny fiovaovany maripana sy ny latsak'orana	1. Eny 2.Tsia (Raha tsia, mifindra faha 187) /___/
Raha eny, inona no voly najanonao? Ary inona novolenao izao?	Anarany taloha : , Anarany voly vaovao :
Novanao ve ny karazam-boly, noho ny fiovana maharitra ny toetr'andro?	1. Eny 2.Tsia (Raha tsia, mifindra faha 187) /___/
Raha eny, inona no voly vaovao nataonao?	*(Omeo ny anarany)*
Novanao ve ny fotoana ny tamberina na "temps de jachere", noho ny fiovana maharitra ny toetr'andro?	1. Tsia, 2. Eny, Nampitomboina ny fotoana ny tamberina, 3. Eny, Nahena ny fotoana ny tamberina /___/
Novanao ve ny haben'ny tanimbolinao noho ny fiovana maharitra ny toetr'andro?	1. Tsia, tsy niova, 2. Eny, nalehibiaziko, 3. Eny, nahenako /___/

189	Niova ve ny fotoam-pambolena, noho ny fiovana maharitra ny toetr'andro?	1. Tsia, 2. Eny lasa aloha, 3. Eny, taraiky /___/
190	Niova ve ny tamberina fambolena na "cycle de culture, noho ny fiovana maharitra ny toetr'andro?	1. Tsia, 2. Eny, niodina haingana (i.e., matetika /isan-taona), 3. Eny, nihena ny cycle isan-taona /___/
191	Araka ny fiovana maharitra momba ny toetr'andro, niova ve ny fotoana famokarana na fiotazana vokatra?	1. Tsia, 2. Eny, lasa aloha ny fotoam-pamokarana, 3. Eny, taraiky ny fotoam-pamokarana /___/
192	Novanao ve ny zezika mba hiatrehana ny fiovany maharitra ny toetr'andro?	1.Tsia, 2. Eny, nampitomboana ny zezika, 3. Eny , nahena ny zezika /___/
193	Araka ny fiovana maharitra ny toetr'andro, Nisy nataonao ve ireto zavatra manaraka ireto hanatsarana ny famokarana: Eny Tsia	1.Mampiatra ny fiarovana ny nofontany sy ny rano? 2. Mampitombo ny toeram-pambolena? 3.Manao ala vadim-boly na "agroforesterie"? 4.Mifindra tanimboly? 5.Manamboatra sompitra ho an'I vokatra?
194	Araka ny fiovana maharitra momba ny latsak'orana, nataonao ve ireto zavatra ireto mba hisiany rano ara-dalana: Eny Tsia	1.Fitarihana rano hampiasaina ao an-trano? 2. Fanamboarana lava-drano hanondrahana ? 3.Manamboatra toha-drano? 4. Fitarihana rano ho ho an'ny voly? 5.Fitarihana rano ho an'ny fiompiana?
195	Araka ny fiovana maharitra ny toetr'andro, nisy olona tao an-tranonareo ve nieritreritra ny hiala eto an-tanana?	1. Eny 2. Tsia /___/
196	Araka ny fiovana maharitra momba ny toetr'andro, mieritreritra ny tsy hamboly intsony ve ianao?	1. Eny 2. Tsia /___/
197	Araka ny hevitrao , iza amin'ireto karazan'asa ireto raha misy amin'ireo no ahafana manampy ny tokatrano hiatrika ny loza ary hanatsara velontena : Eny Tsia	1.Fiofanana momba ny fambolena? 2. Fionana fanampiny momba ny famokarana ? 3. Fionana fanampiny momba ny fiompiana? 4. Fanampiana ara-pitaovana? 5. Fampindramam-bola? 6. Fampitomboana ny sakafo? 7. Fanamboarana sompitra eo an-tanana? 8. Fanamboarana sompitra ho an'ny fokonolona ? 9. Fanamboarana toha-drano ? 10. Fampianarana miompy tantely? 11. Hafa (lazao) :
Fanamarihana ho an'ny mpanadihady. (Raiso an-tsoratra ny fanampi-panazavana izay azona avy @ paikady entiny tantsaha hiatrehana ny olana ara-pamokarana sy ny velon-tena, izay tsy hitanao tao anatin'ity fanadihadiana ity. Raha misy fanontaniana manahirana ny tantsaha ny mamaly azy dia mariho hoe inona.)		

FANONTANIANA FANAMPINY

1. Isaky ny misy cyclone ve dia simba ny trano raha mandala ny cyclone: Eny_____ Tsia_____
2. Raha simbany cyclone ny tranonareo:
    a. Inona no karazana **hazo** alainareo hanamboarana izany
    b. Hatraiza ny halavirana hakana izany taloha:_____Ankehitriny:
    (Omeo ny ora sy ny halavirany ala hakany izany, na ny anarany ala alehany)

    c. Inona no karazana **Tafo (raha bozaka na satrana)** alainareo hanamboarana izany:
    d. Hatraiza ny halavirana hakana izany taloha:_____ Ankehitriny:
    (Omeo ny ora sy ny halavirany ala hakany izany, na ny anarany ala alehany)

Annexe. 2. Fanontaniana mikasika ny harena voa-janahary ampiasain'ny tantsaha mba hiatrehany ireo loza voazajnahary

Tanjona: *Ny tanjona ankapoben'ity fanadihadiana ity dia ny ahafantarana fifandraisany ny paikady na nyny velontena ny tantsaha hiatrehana ny loza voajanahary sy ny harena voajanahary manodidina.*

Anarany mpanadihady:_____

Daty feno nanaovana fanadihadiana:_____

Ora nanombohany fanadihadiana:_____

Ora nifarananany fanadihadiana: _____

Tanana:_____

Fokontany:_____

Firaisana: Fivondronana: _____

Daty Feno nanaovana ny fanadihadiana			Anarana ny mpanadihady
Andro	Volana	Taona	

12. Ny mombamomban ny olona nohadihadiana

	Anarany nohadihadiana	
1	Lahy sa vavy?	/___/ Lahy /___/ vavy
2	Laharany tokatrano	
3	**Laharany Takelaka fanadihadiana**	

A. Fanontaniana mikasika ny harena voa-janahary ampiasain'ny tantsaha

Laharany Fanontaniana	**Fanontaniana**
	Numerao manokana
	Toerana
	Karazamboly
Name	Anarany vavy
code1	Codes vavy
Question 1	Lahy sa vavy
Question 2	Raim-pianakaviana
Question 3	Anarany lahy
Code 2	Codes lahy
Question 4	Isan'olon so an-tonkatrano
Question 5	Laharany ny takelaka
Question 7.1.1	Fitaovana nanaovana rindrina (2001):1> fotaka, 2: rofia, bozaka . Bamboo. 3: hazo, 4: biriky simenitra, 5: fanitso,
Question 7.1.2	Fitaovana nanaovana rindrina (2011):1> fotaka, 2: rofia, bozaka . Bamboo. 3: hazo, 4: biriky simenitra, 5: fanitso,
Question 7.2.1	Fitaovana nanaovana tafo (2001):1> fotaka, 2: rofia, bozaka . Bamboo. 3: hazo, 4: biriky simenitra, 5: fanitso,
Question 7.2.2	Fitaovana nanaovana tafo (2011):1> fotaka, 2: rofia, bozaka . Bamboo. 3: hazo, 4: biriky simenitra, 5: fanitso,
Question 8.0	Tanàna
Question 9.1	Fokontany

	codes of fokontany
Question 10.1	Kaominina
	Codes of municipalitie
Question 11	Distrika
Question 12	Daty nahaterahana
Q1.a	Hanaovana trano (taloha- Ankehitriny)
Q1.b	Hatao kitay (taloha- Ankehitriny)
Q1.c	Hanaovana asa tanana (taloha- Ankehitriny)
Q1.d	Zavatra hafa? Inona? (taloha- Ankehitriny)
Q1.e	Hamidy? (taloha- Ankehitriny)
Q1.f	Lavitra ve ny (taloha- Ankehitriny)
Q1g	Maka hazo so anaty ala ve (taloha- Ankehitriny)
Q1.h	Oviana no tsaroanao nihena ny hazo?.
Q.1.i	Mbola ampy ve ny hazo fampiasa?
Q.1j	Misy mandrara ve ny fakana hazo?
Q.1k	Firy ny hazo azo ao antin'ny indray andro taloha?
Q.1l	Firy ny hazo azo ao anatin'ny indray andro amin'izao fotoana izao?
Q2.1	Maka tantely any an'ala ve ianao taloha?
Q2.2	Isaky ny volana inona ianao no maka izany an'ala?
Q2.3	Betsaka ve no alainao amin'izany?
Q2.4	Maka tantely ao an'ala ankehitriny?
Q2.5	Oviana no nanomboka nihena ny tantely?
Q2.6	Mbola ampy ve ny tantely?
Q2.7	Misy mandrara ve ny fakana tantely?
Q2.8	Firy litatra no azo isaky ny maka taloha?
Q2.9	Firy litatra no azo isaky ny maka amin'izao fotoana izao?
Q2.10	Amidinao ve ny tantely azo?
Q3.1	Mihaza lambo any an'ala ve ianao taloha?
Q3.2	Firy no azo rehefa mihaza taloha
Q3.3	Firy no azo rehefa mihaza amin'izao fotoana izao?
Q3.4	Isaky ny firy andro ianao no mihaza any an'ala?
Q3.5	Mihaza lambo ao an'ala ve ankehitriny?
Q3.6	Oviana no nanomboka nihena?
Q3.7	Mbola ampy ve ny lambo?
Q3.8	Misy mandrara ve ny fihazana lambo?.
Q3.9	Amidinao ve ny lambo azo?
Q4.1	Mihaza fanihy any an'ala ve ianao taloha?
Q4.2	Firy no azo rehefa mihaza taloha
Q4.3	Firy no azo rehefa mihaza amin'izao fotoana izao?
Q4.4	Isaky ny firy andro ianao no mihaza fanihy?

Q4.5	Mihaza fanihy ao an'ala ve ankehitriny?
Q4.6	Oviana no nanomboka nihena?
Q4.7	Mbola ampy ve ny fanihy ?
Q4.8	Misy mandrara ve ny fihazana fanihy?
Q4.9	Amidinao ve ny fanihy azo?
Q5.1	Mihaza sokina any an'ala ve ianao taloha?
Q5.2	Firy no azo rehefa mihaza taloha
Q5.3	Firy no azo rehefa mihaza amin'izao fotoana izao?
Q5.4	Isaky ny firy andro ianao no mihaza sokina?
Q5.5	Mihaza sokina ao an'ala ve ankehitriny?
Q5.6	Oviana no nanomboka nihena?
Q5.7	Mbola ampy ve ny sokina ?
Q5.8	
Q5.9	Misy mandrara ve ny fihazana sokina?.
Q5.10	Amidinao ve ny sokina azo?
Q5.1	Mihaza vorona any an'ala ve ianao taloha?
Q5.2	Firy no azo rehefa mihaza taloha
Q5.3	Firy no azo rehefa mihaza amin'izao fotoana izao?
Q5.4	Isaky ny firy andro ianao no mihaza vorona?
Q5.5	Mihaza vorona ao an'ala ve ankehitriny?
Q5.6	Oviana no nanomboka nihena ny vorona?.
Q5.7	Mbola ampy ve ny vorona ?.
Q5.8	Misy mandrara ve ny fihazana vorona
Q5.9	Amidinao ve ny vorona azo?
Q6.1	Misy biby hafa hazainao ve taloha?
Q6.2	Inona?
Q6.3	Firy no azo rehefa mihaza taloha
Q6.4	Firy no azo rehefa mihaza amin'izao fotoana izao?
Q6.5	Isaky ny firy andro ianao no mihaza biby hafa?
Q6.6	Mihaza io biby hafa fihinana ao an'ala ve ankehitriny
Q6.7	Oviana no nanomboka nihena?
Q6.8	Mbola ampy ve ny biby hafa fihinana ?
Q6.9	Misy mandrara ve ny fihazana biby hafa?
Q6.10	Amidinao ve ny biby hafa azo?
Q7.1	Mioty voankazo any an'ala ve ianao taloha?
Q7.2	Firy harona no azo rehefa mioty taloha
Q7.3	Firy harona no azo rehefa mioty amin'izao fotoana izao?
Q7.4	Isaky ny firy andro ianao no mioty voankazo?
Q7.5	Moty voankazo ao an'ala ve abkehitriny?
Q7.6	Oviana no nanomboka nihena ny voankazotao an'anla?
Q7.7	Mbola ampy ve ny voankazo ?
Q7.8	Misy mandrara ve ny fiotazana voankazo?
Q7.9	Amidinao ve ny voankazo azo?

Q8.1	Mioty oviala any an'ala ve ianao taloha?
Q8.2	Firy harona no azo rehefa mioty taloha
Q8.3	Firy harona no azo rehefa mioty amin'izao fotoana izao?
Q8.4	Isaky ny firy andro ianao no mioty oviala?
Q8.5	Miotyoviala ao an'ala ve ankehitriny?
Q8.6	Oviana no nanomboka nihena ny oviala?
Q8.7	Mbola ampy ve ny oviala ?
Q8.8	Misy mandrara ve ny fiotazana oviala?
Q8.9	Amidinao ve ny oviala azo?
Q9.1	Mioty hovitra any an'ala ve ianao taloha?
Q9.2	Firy harona no azo rehefa mioty taloha
Q9.3	Firy harona no azo rehefa mioty amin'izao fotoana izao?
Q9.4	Isaky ny firy andro ianao no mioty hovitra?
Q9.5	Mioty hovitra ao an'ala ve ankehitriny?
Q9.6	Oviana no nanomboka nihena?
Q9.7	Mbola ampy ve ny hovitra ?
Q9.8	Misy mandrara ve ny fiotazana hovitra?
Q9.9	Amidinao ve ny hovitra azo?
Q10.1	Mioty zavatra fanaovana asa tanana ve taloha.
Q10.2	Firy harona no azo rehefa mioty taloha
Q10.3	Firy harona no azo rehefa mioty amin'izao fotoana izao?
Q10.4	Isaky ny firy andro ianao no mioty zavatra fanaovana asa tanana
Q10.5	Maka zavatra fanaovana asa tanana ao an'ala ve ankehitriny?.
Q10.6	Oviana no nanomboka nihena?
Q10.9	Mbola ampy ve ny zavatra fanaovana asa tanana ?
Q10.10	Misy mandrara ve ny fiotazana zavatra fanaovana asa tanana?
Q10.11	Amidinao ve ny zavatra fanaovana asa tanana azo?
Q11.1	Mioty fanafody any an'ala ve ianao ve taloha?
Q11.2	Firy harona no azo rehefa mioty taloha
Q11.3	Firy harona no azo rehefa mioty amin'izao fotoana izao?
Q11.4	Isaky ny firy andro ianao no mioty fanafody?
Q11.5	Mioty fanafody ao an'ala ve ankehitriny?
Q11.6	Oviana no nanomboka nihena?
Q11.7	Mbola ampy ve ny fanafody ?
Q11.8	Misy mandrara ve ny fiotazana fanafody?
Q11.9	Amidinao ve ny faanfody azo?
Q12.1	Noho ny loza voajanahary, Ampy hoa any ankohonanao ve ny tany volenao
Q13.1	Rha tsia inona @ ireto no ataonao: Mitady tany hafa hanaovana tavy
Q13.2	Raha tsia inona no ataonao? Mitady tany hafa hanaovana tavy
Q13.3	Mividy tany ve?
Q13.4	Tsy maboly intsony?
Q13.5	Hafa Lazao

Annexe .3. Fanadihadihana momba ny Rivodoza

Mariho eto ny ora nanombohany fanadihadiana:_____ Mariho eto ny Ora nifaranan'ny fanadihadiana:_____ Fitondrana ny fanotaniana:

	Daty Feno nanaovana ny			Anarana
Asa	Andro	Volana	Taona	
Fanadihadiana				
Fanamarinana eny an-toerana				
Fanamarinana ao amin'ny birao				
Firaketana ny antonta-kevitra				

1. **Ny mombamomban ny olona nohadihadiana (Fanamarihana: Tsara raha fenoina mialohan'ny fanombohan'ny fanontaniana ny A-E araky ny fiche ny tokatrano t@ fanadihadiana voalohany)**

	Anarany nohadihadiana
A	Lahy sa vavy?
B	Lohan'ny fianakaviana ve ianao? (Eny , Tsia)
C	Raha "tsia" iza no anarany loham-pianakaviana
D	Laharany tokatrano/ N® de ménage: (*FANAMARIHANA : Tokony hitovy @ kaharany tokatrano t@ fanadihadiana voalohany)*
E	**Laharany Fiche d'enquete**

Fanontanina mikasika ny fiantraikany rivo-doza t@ Febroary 2012 teo @ velontena ny tantsaha

Hamafiny sy fiantraikany rivo-doza

1.Nanao ahoana ny heriny rivo-doza Giovanna t@ Febroary (2012) raha oharina t@ ireo rivo-doza nisy tao anatiny 10 taona lasa?	1. Mafy noho ireo rivo-doza teo aloha; 2. Mitovitovy @ teo aloha, 3.Malemy noho ny teo aloha
2.Ahoana no andaharanao ny fiantraikan'io rivo-doza io @ ireto zavatra ireto:	(ampiasao ireto mari-drefy ireto @ fijerena ny fiantraikany: 1: tsy nsy fiantraikany; 2: ambany ny fiantraikany; 3:antonony ; ary 4:) Nahery be (Mariho isan-tsokajiny: 1.tsy nisy fiantraikany 2.Ambany, 3 Antonony: a)Tondra-drano,) Fahasimbany trano,) Fahasimban'ny sekoly sy ny fiangonana, d)Fahasimban'ny lalana, e)Fahasimban'ny voly, f)faharatrana na fahafatesan'nyy biby fiompy, g) Faharatran'ny olona, h)Fisian'ny zavatra ao an'ala izay fampiasany olona @ ankaponeny (hazo, kitay, tantely , zavatra hafa…)

Fiomanana @ fiatrehana ny rivo-doza : Eny sa Tsia

1. Efa naheno filazana mialoha momba ny fihaviany rivo-doza ve ianareo?	1.Eny 2. Tsia Raha tsia mifindra @ fanontaniana faha 13
2. Raha 'Eny', Inona @ ireto no nahenonareo ny rivo-doza: (Apetraho daholo izay lazainy)	1. Radio, 2. Tele, 3. Fikambanana eto an-tanana, 4.Fanjakana, 5.Mpifanolo-bodirindrina, 6.Havana, 7. Hafa? (Lazao)
3. Nisy zavatra nataonao ve mba hampihena ny fiantraikany rivo-doza @ trano fonenanao	Eny sa Tsia *(Raha tsia mifindra @ fanontaniana faha- 7)*
4. Raha 'eny' , inona no nataonao t@ tranonao	1. Namafisina ny tafo (mba tsy hiala)2., Namafisina ny varavaran-kely sy

	varavaram-be 3. Hafa (lazao hoe inona)
5. Nisy zavatra nataonao ve mba hampihena ny fiantraikany rivo-doza @ ankohonanao?	*1.* Eny sa 2. Tsia *Raha tsia mifindra @ fanontaniana faha- 9*
6. Raha 'eny' , inona no nataonao mba niomanany ankohonanao:	1. Nampiana ny tahirin-tsakafo ao an-trano?, 2. 2Nanagona rano madio hampiasana aoriany rivo-doza?, 3.Nifindra toerana azo antoka toy ny sekoly na fiangonana na trano hafa?, 4.Hafa? Lazao_____
7. Nisy zavatra nataonao ve mba hampihena ny fiantraikany rivo-doza @ fambolena sy fiompiana?	1. Eny sa 2. Tsia *(Raha tsia mifindra @ fanontaniana faha- 11)*
8. .Raha 'eny' , inona no nataonao t@ izany	1.Nafindra @ toerana maina sy azo antoka ny vary sy ny sakafo mba tsy ho simba na tratran'ny rano, 2. Nafindra t@ toerana azo antoka ny biby fiompy, 3. Lazao
9. .Nisy fikambanana ve nanome toro-hevitra anareo @ fiatrehana ny rivo-doza?	1. Eny sa 2. Tsia
10. Raha eny , iza avy izy ireo?	*(Omeo ny anarany)*
11. Nitady toerana hialofana ve ianareo sa nijanona tao an-trano ihany nadritra ny rivo-doza?	*1.* Nifindra toerana, 2. Nijanona tao an-trano (Raha '2', mifindra @ fanontaniana14)
12. Raha nifindra toerana ianareo, taiza ianareo no nandeha?	1. Tranon'ny Havana na mpifanolo-bodirindrina, 2.Sekoly, 3.Fiangonana, 4.Tanan hafa, 5.Hafa (lazao):_____
13. FIry ny trano simba teto an-tanananareo?	1.Tsy nisy, 2.Latsaky ny ampahaefany 25%, 3.25-50%, 4 .Mihoatra ny an-tsasany (>50%), 5.Simba daholo
14. Inona no karazana trano tena ravan'ny rivo-doza:	1. Trano vita @ fotaka?, 2.Trano vita @ ravinala, rofia na bambo, 3.Trano biriky na ciment, 4.Trano tole, 5.Trano hazo planche, 6.Ireo karazana trano ireo dia simba daholo)
15. Samihafa ve ny fahasimban'ny trano araka ny toerana misy azy?	1.Eny, samihafa ny fahasimban'ny trano araka ny toerana misy azy , 2Tsia, nitovy daholo ny fahasimban'ny trano arak any toerana misy azy , 3.*(Raha '2', dia mifindra @19)*
16. Raha eny, trano taiza no tena nisy simba?	1.Ireo trano amoron-drano?, 2. Ireo trano eny @ an-tapo-tanety?3. Ireo trano eny @ lohasaha na valle na cuvette na, 4.Ireo trano eny @ lemaka, 5.Mitovy daholo ny fahavoazany trano
17. Samihafa ve ny fahasimban'ny trano araka ny toerana misy azy?	1..Eny, samihafa ny fahasimban'ny trano araka ny toerana misy azy, 2. Tsia, nitovy daholo ny fahasimban'ny trano arak any toerana misy azy , 3. *(Raha '2', dia mifindra @19)*
18. Samihafa ve ny fahasimban'ny trano araka ny toerana misy azy	1. Eny, samihafa ny fahasimban'ny trano araka ny toerana misy azy, 2. Tsia, nitovy daholo ny fahasimban'ny trano arak any toerana misy azy *(Raha '2', dia mifindra @19)*
19. Raha eny, trano taiza no tena nisy simba?	1. Ireo trano amoron-drano?, 2. Ireo trano eny @ an-tapo-tanety?3. Ireo trano eny @ lohasaha na valle na cuvette na, 4..Ireo trano eny @ lemaka, 5. Mitovy daholo ny fahavoazany trano
20. Nanao ahoana ny fahasimban'ny tranonao t@ rivo-doza teo?	1. Tsy simba, 2. Rava ny tafo, 3. Simba ny tafo sy ny rindrina, 4. Rava tanteraka ny trano, 5. Hafa? lazao
21. Tena namboarina tenteraka ve ny tranonao taorian'ny rivo-doza?	2. Eny sa 2 Tsia (Raha tsia mifindra @ 29)
22. Raha eny, nividy fitaovana ve ianao nanarenana ny trano sa naka fitaovana tany anaty ala?	Nividy fitaovana, 2. Naka fitaovana tany anaty ala (oh: hazo,…), 3. Izy roa (ny sasany novidina ny sasany nalaina tanaty ala)), (Raha'1', Mifindra @ 23)
23. Raha naka fitaovana tany anaty ala nanamboarana trano, hafiriana no nakana izany?	1. Latsaky ny ora iray, 2. 1-2 ora, 3. 2-4 ora, 4 .Nahery ny 4 ora
24. Inona no fitaovana novidinao nanarenana ny trano?	1.Tole natao tafo, 2. Biriky, 3. Ciment, 4. Concrete, 5. Hazo, 6. Hafa lazao
25. Tokony ohatrinona no vidin'ireo fitaovana	2. (Soraty izay lazainy)

nilainao? (Ariary)	
26. Ampahafiriny vola miditra aminao isan-taona ny vidin' izany fitaovana izany?	1. Latsaky 25%, 2. Anelanelan'ny 25% sy 50%?, 3. Anelanelan'ny 50% sy 4. 5% , 5. Nihoatra 75%
27. Ahoana no nandoavanareo izany vola vidina fitaovana izany:	1.T@ vola tahiry? 2.Nivarotra biby fiomby?3. Nivarotra vokatra?4. Nivarotra tahiry hafa?5. Nindrana vola t@ banky na t@ birao fampindramam-bola madinika?6. Nindrana vola t@ namana na havana?7. Niasa tany an-drenivohitra?8. Nitady asa tselika?9.Hafa? (Lazao)_____
28. Iza @ ireto karazan'olona ireto raha nisy no nanampy anao nanarina ny trano simba t@ rivo-doza:	1.Havana akaiky?,2.. Havana lavitra?, 3. . Namana/ mpiara-monina?, 4. Fikambanana (fikambanana ifotony na fikambanana mpanampy?, 5. Hafa lazao:¬¬¬_____
29. Hafiriana no nanamboaranao ny trano	1.Andro vitsivitsy , 2.Iray herinandro, 3.Roa herinandro, 4.Iray volana

Fiantraikany rivo-doza eo @ famokarana

30. Firy isan-jato ny voly varinao no simba t@ cyclone?	1.Tsy nisy, 2.Latsaky ny 25% , 3. Anelanelan'ny 25-50 % , 4. Anelalenan'ny 50-75% , 5.Mihoatra 75 isan-jato no simba, 5. Tsy manana tanimbary)
31. Firy isan-jato ny voly hafa nataonao no simba t@ cyclone?	1. Tsy nisy, 2. Latsaky ny 25% , 3. Anelanelan'ny 25-50 % , 4. Anelalenan'ny 50-75% ,5. Mihoatra 75 isan-jato no simba
32. Ny voly t@ toerana taiza no tena simba?	1.Teny @ lohasaha, 2.Nanamborona ny renirano,3.Teny an-tampo-tanety,4.Nitovy daholo ny fahasimbany,5.Hafa (lazao):_____
33. Mbola hiasanao ihany ve ilay tanimboly simba teo ato ho ato?	1. Hambolena indray, 2.Tsy hamboly eo intsony, 3.Hiandry @ fotoam-pambolena manaraka, 4.Hijery karazana voly hafa hatao eo
34. Hafiriana no ilainao hanarenana ny voly simba?	1. Andro vitsivitsy ,2. Iray herinandro,3.Roa herinandro,4.Iray volana,5.Mihoatra ny iray volana

Fiantraikany rivo-doza @ fahavitan-tena ara-tsakafo

35. Simba daholo ve ny tahirim-bokatrareo t@ rivo-doza teo?	Eny, 2.Tsia,3.Tsy manana tahirim-bokatra) *(Raha'3', Mifindra @ 38)*
36. Raha eny, firy isan-jaton'ny tahirim-bokatrareo no simba?	1.Latsaky ny25%, 2. 25-50%,3.3. 50-75%, 4.. Mihoatra ny 75%
37. Manana tahirim-bokatra ampy ho anareo mandritra ity taona ity ve ianareo (mandrapahatongan'ny fotoam-pamokarana manaraka)?	Eny sa 2.Tsia*(Raha eny mifindra @ 40)*
38. Raha tsia, firy volana ny tokatranonao no tsy ampy sakafo noho ny rivo-doza?	*(Lazao ny isan'ny volana)*
39. Inona no paikady nataonao niatrehana izany tsy fahampiantsakafo izany: (Eny sa Tsia)	*1. Nahena ny fatrany sakafo (Ny fatrany sy ny hatetiny)?2.Naka sakafo dia?3. Nividy sakafo?4. 4.Nahazo sakafo t@ mpifanolo-bodirindrina?,5. Nahazo sakafo t@havana?6. Nahazo sakafo fanampiana t@ fanjakana na fikambanana mpanampy?7. Hafa :… (Lazao)*
40. Iza no fikambanana nanome fanampiana ara-tsakafo raha nisy:	*Lazao ny anarany*

Fiantraikany rivo-doza @ fahasalamana sy ny velontena

41. Nisy zavatra nataonao ve itandrovana ny fahasalamany ankohonanao sy hananany sakafo ara-pahasalamana t@ iny rivo-doza iny?	1. Eny sa 2. Tsia Fiantraikany rivo-doza @ fahasalamana sy ny velontena
42. Fiantraikany rivo-doza @ fahasalamana sy ny velontena	1.Nampirina vokatra mba tsy ho tratry ny hamandoana,2. Fiantraikany rivo-doza @ fahasalamana sy ny velontena, 3. Fiantraikany rivo-doza @ fahasalamana sy ny velontena, 4. Fiantraikany rivo-doza @ fahasalamana sy

	ny velontena, 5. Fiantraikany rivo-doza @ fahasalamana sy ny velontena, 6. 6.Hafa (lazao):…..
43. Fiantraikany rivo-doza @ fahasalamana sy ny velontena	1. Eny sa Tsia
44. Taiza ianareo no naka rano fisotro sy nandrahoana sakafo taorian'ny rivo-doza teo?	1.Paompin-drano-pokonolona, 2. Fatsakam-pokonolona, 3.Paompin-dranon'olona hafa, 4. Fatsan'olona hafa, 5. Dobo, 6.An-drenirano, 7. Farihy, 8.Hafa (Lazao):
45. Nisy aretina nahazo anao ve na ny olona tao anatiny ankohonanao taorian'ny rivo-doza iny?	1. Eny sa 2 Tsia
46. Raha eny, aretina inona? (Raha tsia, mifindra @ manaraka)	1.Aretin-kibo, 2.Cholera, 3.Hafa (Lazao)____
47. Taorian'ny rivo-doza teo, nisy fepetra noraisinao ve hampihena ny vola nivoaka tao an-tokatrano: eight	1.Nalana tsy nianatra ny zazalahy, 2.Nalana tsy nianatra ny zazavavy?, 3.Nampitomboana ny asan'ny ankizy eny an-tsaha?, 4. Nalefa nitady as any ankizy lehibe?, 5.Nitady asa ny olon-dehibe? 6. Nampanofana tanimboly?, 7.Nitrosa na naka trosa?, 8.Nindram-bola t@ namana?, 9.Hafa

Fiantraikany rivo-doza @ foto-drafitr'asa iombonana

48. Hafiriana ny Sekoly no nikatona noho ny rivo-doza?	1.Iray andro, 2.iray herinandro, 3.Herinandro vitsivitsy,4.Iray volana,5.Mihoatra ny iray volana,6.Nisokatra foana
49. Hafiriana ny Fiangonana no nikatona noho ny rivo-doza?	1.Iray andro,2.iray herinandro,3.Herinandro vitsivitsy,4.Iray volana,5.Mihoatra ny iray volana,6.Nisokatra foana
50. Hafiriana ny Tsena no nikatona noho ny rivo-doza?	1.Iray andro,2.iray herinandro,3.Herinandro vitsivitsy,4.Iray volana,5.Mihoatra ny iray volana,6.Nisokatra foana
51. Adiny firy no lany namonjena ny tsena raha nikatona ny tsena akaiky anareo indrindra?	1. Latsaky ny 1 ora,2.1-2 ora,3.2-4 ora3.Mihoatra ny 4 ora
52. Taorian'ny rivo-doza, nihena ve ny vola niditra taminareo?	1.Tsia , tsy nihena,2.Latsaky ny 25% ny fihenany,3.Anelanelan'ny 25 % sy ny 50% ny fihenany,4.Anelanelan'ny 50 sy 75% ny fihenany,5.Nihoatra ny 75% ny fihenany

Fanampian'ny fikambanana

53. Nahazo fanampiana t@ fikambanana ve ny ankohonanao taorian'ny rivo-doza?	1. Eany 2. Tsia *(Raha tsia, mifindra @ 56)*
54. Raha eny, lazao daholo ny fikambanana miasa eo an-tanana ary lazao na nanampy na tsia	*(Lazao daholo ny fikambanana miasa eo an-tanana ary lazao na nanampy na tsia*
55. Taorian'ny rivo-doza, inona @ ireto fanampiana ireto no azonareo?	1. Torolalana ara-teknika mny famokarana?2.Fampitaovana ara-pamokarana (oh: masomboly, zezika)?3. Fanamboarana lakan-drano na fakana rano?4. Fahazoana vaovao momba ny lalam-barotra?5.Fiofanana momba ny famokarana?6.Fanampiana ara-tsakafo?7.Findramam-bola?8. Fahazoana fitahirizam-bola?9.Fahazoiana vola-na vonjy taitra?10.Fanampiana @ fifindra-monina?11.Fitaovanana fanarenana ny trano simba noho ny loza voajanahary?12.Fampitaovana ara-pamokarana?13.fanampiana avy @ fokonolona hanarenana ny simba?14.Hafa (Lazao)
56. T@ ireo fanampiana voalaza teo ambony ireo, inona @ ireo no tena nilainao niatrehana ny loza?	*(Ampiasao ny laharan'ireo fanampiana eo ambony)*
57. Amin'ny fiatrehana ny loza manaraka, inona no mety hataonao mba hiovana @ teo aloha?	*1. Hifindra toerana azo antoka mialohan'ny fihavian'ny rivo-doza,2.Hampitomboana ny tahirim-bokatra,3.Hamidy ny tahirim-bokatra mba hahazoana vola,4.Harovana tsar any biby fiompy mba tsy ho simban'ny rivo-doza, 5.Hatqao mafy orina tsara ny trano,6.Jerena mialoha izay toerana hifindrana raha sanatria ka misy loza, 7.Hafa? Lazao*

Annexe 4: Analyse spatiale de l'evolutuion de la couverture vegetale de 2000 a 2010 dans le corridor Ankeniheny Zahamena

To confirm the perception of depletion of forest products by the smallholder farmers within the target sites, we compared the 2001 and 2011 vegetation maps to detect change in the type of land use cover. We used Conservation International's standard methods for conducting the spatial and temporal analysis of the vegetation cover and land use; then, we used (Conservation International, 2009; Andrieu and Mering, 2008). Four (4) scenes of Landsat images TM (Thematic Mapper) were used to characterize vegetation cover in 2000 and the corresponding scenes in 2010. We followed the steps below of the analysis

Acquisition and selection of satellite imageries

We downloaded freely Landsat TM from the NASA website (https://glovis.usgs.gov), additional Landsat images were bought from the South African National Space Agency (SANSA) (with 300usd/scene). During the selection of images to be analyzed, images with the least cloud cover was prioritized since cloud cover is very common and persistent in the area. After the cloud cover, the next criteria for selection were the season: we prioritized dry season as the contrast between forest and annual perennial crop is evident during this season.

Georeferencing and image matching,

Georeferencing is an important step in change analysis, as images from different dates tend to have a little shift, which will show as a change in the resulting images if not corrected. The two images were co-registered and paired using common features identifiable in both images. Georeferencing has been done as rigorous as possible with an allowable error less than a pixel (registration error less than 30m). At the end of this process the two images were stacked together to create a singe multi-date images with 12 channels (or band consisting of band 1, 2, 3, 4, 5, 7 of each Landsat image)

Screen display

We loaded twice in the display window the 12 channel images. To show the change between the two images loaded, the lower layer image was configured to show the earlier (old) date, for that, band combinations of 4-5-3 (RGB) were used; similarly the upper image were configured to show the later date (new) and the band combination for that was 10-11-9 (RGB) which is just the landsat band 4, band 5, band 3 of the second image in the stack. .The "swipe" tool was used to visualize the two image dates iteratively and contrast of each image can be changed to show subtle differences in contrast so that a feature of interest appears evident.

Search training sites

Training sites selections starts with the selection of areas that did not change, and we know for sure what it is, based on expert knowledge or ancillary data that we analyzed. Training sites consist of a polygon drawn in a homogenous area in the image. Training sites will serve as reference for the software to extrapolate land use value in the whole images based on eigenvalue of each individual pixel.

Classification and filtering of pixels and analysis of changes

Supervised classification has been used, based on predefined class (land use type) that has been defined earlier in the training sites. This kind of classifications requires the user to have knowledge of the area being classified.

Single classification of multi-date images was adopted instead of classifying each date separately and combining them at the end. This method is quicker, simpler and avoids misclassification due to seasonality. Also, the resulting classification already includes change in each land use, removing some extra steps if we were to classify each image individually.

At the end of the classification, a majority filter using a 3x3 pixels moving window was applied to remove isolated misclassified pixels. After this, the function "sieve" was applied to remove any entities that were less than 2 hectares in sizes. This results in a minimum mapping unit of 2ha for the final product.

For the data interpretation

To establish the change in land use category for the area of interest, the deforestation map analysis (ONE, 2013) was overlaid with Vegetation Atlas, and the following rules were applied: a) If it was forest 2000 and it was deforestation then the new class is Degraded humid forest, b) If it was forest 2000 and it was forest in the deforestation analysis, then it is staying as the original class (humid forest), and c) There were no change in the other land use category.

The rule applied leaves a margin of errors: a0 cultivated areas may now be degraded humid forest or grassland/wooded grassland mosaic, b) wooded grassland and grassland may have evolved into secondary forest and then cut down again to join the cultivated area class, and c) degraded humid forest could be recycled to agriculture and may be now cultivated area, or may even be abandoned to fallow and should be in the class of grassland/wooded grassland mosaic

We don't have the mean to verify these errors at the time being, so we were accounting for the change only from forest to degraded humid forest.