Economic Evaluation of Asella Model-III Multi-crop Thresher

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Abstract: 6he!t is one o2 the most popul!r crops in -rsi 7one pro"uce" co1ering m! or 2!rml!n"s speci!ll5 on mi"-highl!n"s !n" p!rts o2 highl!n" !re!s. $ts pro"uction s5stem is more !"1!nce" !n" supporte" b5 both biologic!l !n" mech!nic!l technologies rel!ti1e to other crops in this !re!. 8ut the mech!ni7!tion o2 whe!t is thre!tene" b5 topogr!phic!l in!ccessibilit5 in most highl!n" !re!s o2 the 7one. +o sol1e this problem -sell! -gricultur!l .ngineering rese!rch center "e1elope" !n" teste" its thir" 1ersion multi-crop thresher. 8e2ore the wi"er multiplic!tion !n" "issemin!tion o2 the technolog5, technic!l, economic!l !n" soci!l !ccept!nce !n" 2e!sibilit5 o2 the m!chine h!s to be stu"ie". +here2ore, this rese!rch !cti1it5 w!s initi!te"with the ob ecti1es o2 e1!lu!ting 2in!nci!l, economic!l!n" soci!l 2e!sibilit5 o2 the m!chine 1is-9-1is tr!"ition!l !n" combines h!r1esting metho"s in -rsi 7one un"er 2!rmers: con"itions. -ccor"ingl5, the newl5 "e1elope" -sell! mo"el-$$$ thresher w!s 2oun" to be economic!l comp!re" to tr!"ition!l !nim!l tr!mpling metho".

Keywords: .conomic .1!lu!tion, 3ulti-crop +hresher, /ombine ;!r1esting, (!rti!l 8u"geting, (!5-8!c< (erio", $ntern!l *!te o2 *eturn, %ensiti1it5 -n!l5sis

1. Background and Justification

+he histor5 o2 !gricultur!l mech!ni7!tion in -rsi goes b!c< to 1=#0th when /hil!lo -gricultur!l >e1elopment ?nit (/->?):s 2!rm implement promotion !n" impro1ement section st!rte" the e1!lu!tion !n" comp!rison o2 especi!ll5, loc!l (con1ention!l) h!r1esting !n" threshing 2!rm implements !g!inst impro1e" m!chineries !n" 2oun" subst!nti!l output loss in c!se o2 con1ention!l h!r1esting !n" threshing techni@ues [A1B], [A2B], !n" [A3B]. -2ter th!t e1!lu!tion, /->? continue" the promotion o2 pre h!r1est, h!r1est !n" post h!r1est 2!rm m!chineries until the progr!m w!s 2orce" to "iscontinue b5 polic5 m!<ers in 1='2, e1en though the economic 2e!sibilit5 !n" technic!l 1i!bilit5 o2 the new metho"s were con2irme" [A4B].+he m!in conse@uences o2 promoting the new metho"s "uring 1='2 were reporte" to be the e1iction o2 ten!nts, incre!se" unemplo5ment !n" soil erosion [A5B], [A#B] !n" [A'B].

%ince 1='4, the use o2 -gricultur!l mech!ni7!tion m!chineries b5 in"i1i"u!l sm!ll sc!le 2!rmers w!s tot!ll5 2orbi""en !n" onl5 pro"ucer cooper!ti1es were !llowe" to use those m!chineries until the pro"ucer cooper!ti1es were "ism!ntle" b5 1==1 [A8B]. -2ter the politic!l !n" economic structur!l re2orm o2 1==1, sm!ll sc!le 2!rmers st!rte" bene2iting 2rom the use o2 2!rm m!chineries b5 hiring 2rom pri1!te in1estors !n" some multipurpose cooper!ti1es.

6he!t is one o2 the most popul!r crops in -rsi 7one pro"uce" co1ering m! or 2!rml!n"s speci!ll5 on mi"-highl!n"s !n" p!rts o2 highl!n" !re!s. $ts pro"uction s5stem is more !"1!nce" !n" supporte" b5 both biologic!l !n" mech!nic!l technologies rel!ti1e to other crops in this !re!. ?nless the 2!rmer is resource poor to use, tr!ctor, tr!ctor mounte" pl!nters !n" combine h!r1ester !re !ll !1!il!ble through renting 2rom cooper!ti1es !n" pri1!te m!chiner5 hol"ers. 8ut this mech!nic!l technolog5 inter1ention is constr!ine" b5 in!ccessibilit5 "ue to topogr!ph5 o2 most p!rts o2 the 7one.

3ost 2!rmers h!1ing goo" topogr!ph5 o2 2!rm l!n"s !re hiring combine h!r1esters while some o2 the others !re bu5ing !n"/or hiring the st!tion!r5 motori7e" (engine "ri1en) threshers. >i22erent org!ni7!tions inclu"ing -sell! -gricultur!l engineering rese!rch center, !re m!nu2!cturing "i22erent mo"els o2 this st!tion!r5 engine "ri1en threshers t5pe !n" 2!rmers !re using these technologies. ;owe1er, the

economic 2e!sibilit5 !n" soci!l 1i!bilit5 o2 those !ltern!ti1e metho"s o2 threshing !n" h!r1esting must be !ssesse" !n" comp!re" with con1ention!l metho"s be2ore emb!r<ing on m!ss pro"uction !n" recommen"!tion o2 the techni@ues.

2. Objectives of the Study

+here h!1e been "i22erent !rguments between mech!ni7!tion 2!1oring !n" "is2!1oring groups in .thiopi!n !n" !ll o1er the worl"'s !griculture reg!r"ing the imp!ct o2 !gricultur!l mech!ni7!tion on pro"uction !n" pro"uctilit5. +he mech!ni7!tion 2!1oring groups !rgue th!t net pro"ucti1it5 g!ine" "ue to 2!rm mech!ni7!tion while the !gricultur!l mech!ni7!tion "is2!1oring group who consi"ere" !gricultur!l mech!ni7!tion !s the substitute 2or !nim!l !n" hum!n l!bour"ispl!cing technolog5, !rgue th!t there is no signi2ic!nt net e22icienc5 g!ins in terms o2 higher output !n" no re"uction in pro"uction cost. .1en i2 there higher pro"uction output, it will be o22set b5 higher pro"uction cost speci!ll5 when resources !re 1!lue" in terms o2 soci!l e22icienc5 price r!ther th!n pri1!te e22icienc5 pricesA'B !n" A=B.

+here2ore, this stu"5 is initi!te" to !ssess the economic!l !n" soci!l 2e!sibilit5 o2 st!tion!r5 engine "ri1en threshing metho" 1is-9-1is the combine h!r1esting !n" con1ention!l metho"s/! comp!r!ti1e !ssessment o2 ! m!nu!l sic<ling !n" motori7e" st!tion!r5 m!chine threshing 1is-9-1is ! combine h!r1esting !n" tr!"ition!l threshing in -rsi !n" 6est -rsi with the 2ollowing speci2ic ob ecti1es.

1. +o "escribe the current threshing technologies in -rsi !n" 6est -rsi 7ones

2. -ssess !n" comp!re the socioeconomic pro2it!bilit5 o2!ltern!ti1e h!r1esting !n" threshing technologies

3. Research Methodology

3.1. The Study Area

+his rese!rch w!s con"ucte" in -rsi 7one two "istrictsn!mel5Cemu-bilbilo !n" ;etos!selecte" b!se" on prelimin!r5 in2orm!tion 2or the eDposure/eDperience to st!tion!r5 engine "ri1en threshing m!chine !n" combine h!r1ester 2or hiring in the !re!. 6he!t is the m!in crop in terms o2 l!n" !lloc!tion !n" pro"uction in both "istricts. +here !re !lso e22orts which h!1e been "one to mech!ni7e whe!t 2!rms in these !re!s !n" the e22ort o2 -sell! !gricultur!l engineering rese!rch center c!n be mentione" !s one which "e1elop, mo"i25 !n" !"!pt "i22erent pre-h!r1est !n" h!r1est technologies. *ecentl5, tr!ctor !n" combine h!r1esting !re eDp!n"ing in most p!rts o2 highl!n" !re!s. +here !re some threshing technologies being tr!ns2erre" to 2!rmers in this !re! while their comp!r!ti1e !"1!nt!ges o1er combine h!r1esting !n" tr!"ition!l h!r1esting were not stu"ie".

3.2. Data Type and Methods of Data Collection

8oth prim!r5 !n" secon"!r5 "!t! t5pes were use" in this rese!rch. (rim!r5 "!t! were collecte" 2rom 2!rmers both on 2!rm b!sis b5 chec<lists !n" using structure" @uestionn!ires. +o compute the comp!r!ti1e economics o2 the three threshing mech!nisms,) - *$-- sel! mo"el-3 multi crop thresher w!s use" !n" prim!r5 "!t! w!s collecte" on 2iel". +he "!t! collecte" inclu"e "emogr!phic !n" socioeconomic ch!r!cteristics o2 the respon"ents, in2orm!tion on whe!t pro"uction !n" threshing (whe!t 2!rming ch!r!cteri7!tion). -""ition!ll5, E0> w!s un"ert!<en with <e5 in2orm!nts li<e mo"el 2!rmers, > - s, in1estors o2 !gricultur!l m!chineries rent ser1ice pro1i"ers, !n" "i22erent st!<ehol"ers !t "i22erent le1els. +o collect h!r1esting !n" threshing cost o2 e!ch mech!nism (i.e. to m!<e comp!rison !mong "i22erent threshing mech!nism), !ctu!l !n" estim!tion b5 respon"ents !t e!ch (- w!s collecte" "uring the se!son using - sel! mo"el-3 multi crop thresher, combine h!r1ester !n" loc!lor/tr!"ition!l !nim!l tr!mpling mech!nism on pl!te o2 2iel" c!lle *hogdi/awudima*.

3.3. Data Analysis Methods

>!t! !n!l5sis metho" is "etermine" b5 ob ecti1e o2 the rese!rch, !n" t5pe o2 "!t! collecte". $n this rese!rch !cti1it5, there !re @u!lit!ti1e "!t! which !re 1iews !n" comments 2rom "i22erent eDperts, 2!rmers !n" "e1elopment !gents !n" these "!t! were !n!l57e" @u!lit!ti1el5. +o con"uct the comp!r!ti1e !n!l5sis o2 whe!t threshing techni@ues, p!rti!l bu"geting w!s emplo5e". +o summ!ri7e the "emogr!phic !n" socioeconomic ch!r!cteristics o2 the respon"ents, "escripti1e !n" in2erenti!l st!tistics were emplo5e". +o estim!te the economic 2e!sibilit5 o2 threshing techni@ues, intern!l r!te o2 return !n" m!chine p!5-b!c< perio" o2 engine "ri1en threshing metho" were c!lcul!te"2ollowing A10B.

4. Result and Discussion

4.1. Socioeconomic Characteristics and Resource Ownership of the Respondents

+he result in +!ble 1 shows th!t the me!n !ge o2 respon"ents w!s !bout 45 5e!rs while the me!n e"uc!tion 5e!r w!s 4.=' 5e!rs. +he l!rgest e"uc!tion st!tus w!s 12 gr!"es complete. +he me!n 2!mil5 si7e o2 the respon"ents: househol" w!s !bout siD persons while on !1er!ge e!ch househol" h!s !roun" two economic!ll5 "epen"ent 2!mil5 members. $n ;etos! househol"s he!" !ge w!s higher th!n in C/8ilbilo !n" the5 !re more e"uc!te". >epen"enc5 w!s !lso higher in Cemu-bilbilo "istrict !n" the 1!lues !re !ll signi2ic!nt.

C!n" is the most import!nt resource in 2!rming business !n" the !1er!ge l!n"hol"ing o2 the respon"ents w!s 2.5=hect!res with m!Dimum hol"ing o2 10.88hect!res !n" minimum hol"ing o2 0.13 hect!re per househol".

Table 1. Mean of Socioeconomic Variables of Households.

Variable Description	Lemu-bilbilo	Hetosa	total
; ousehol" he!" - ge	40.58[1]	51.1'	45.28
; ousehol" he!" e"uc!tion	4.23[2]	#.54	4.='
>epen"ent househol" member	2.00[3]	1.3'	1.'5
E!mil5 si7e o2 househol"	5.=2	5.#=	5.83
C!n"hol"ing	2.5'	2.#1	2.5=
- nnu!l income (. +8)	450##	3'15'	3=#8=.88
Ci1estoc< in +C ?	'.5'	#.58	'.05

[1, 2 !n" 3] t-1!lue 2or me!n "i22erence !re signi2ic!nt !t 1, 5 !n" 10G le1el.

4.2. Description of Current Wheat Harvesting and Threshing Mechanisms

+here !re two m! orl5 use" threshing mech!nisms in the stu"5 !re!s while the thir" one is on intro"uction st!ge. 3 !nu!l h!r1esting !n" threshing metho"s !re the most "omin!ting one in highl!n"s o2 Cemu-8ilbilo "istrict while in ; etos!, combine h!r1esting is commonl5 !n" wi"el5 use" metho" o2 h!r1esting. /ombine h!r1esting w!s re-intro"uce" !2ter "own2!ll o2 *Dergue* regime b5 in1estors !n" unions. +he thir" engine "ri1en st!tion!r5 thresher is un"er intro"uction b5 -+- !n" - sell! !gricultur!l engineering rese!rch center. %el!mt5pe thresher w!s multiplie" b5 ministr5 o2 !griculture !n" "istribute" to selecte" "istricts o2)romi! region !n" Cemu-bilbilo "istrict w!s the one inclu"e" in the progr!m. - sell! mo"el-$$$ thresher w!s un"er mo"i2ic!tion !n" pre-eDtension "emonstr!tion since long time !n" currentl5, some 2!rmers in %ire, +i5o !n" Cemu-bilbilo "istricts h!1e bought !n" using the technolog5 b5 renting !s well.

4.2.1. Manual Sickling and Animal Threshing/Trampling (Traditional Harvesting)

+r!"ition!l threshing metho" o2 whe!t comprises !cti1ities o2 h!r1esting, he!ping, tr!nsporting whe!t bun"les, tr!mpling whe!t on the 2iel". +his shows how much the tr!"ition!l h!r1esting s5stem is l!bor intensi1e !n" 2ull o2 "ru"geries. 3 ore th!n '5G o2 2!rmers in Cemu-8ilbilo "istrict !n" onl5 !roun" 3G in ; etos! threshes their whe!t crop m!nu!ll5 (in tr!"ition!l w!5s) while the rem!ining is being threshe" b5 combine h!r1ester.

$n pl!ces where tr!"ition!l (m!nu!l) h!r1esting is common, whe!t crop will be h!r1este" b5 sic<le !n" st!c<e" in the 2iel" 2or some perio" until the 2!rmer 2inishes h!r1esting o2 his others 2iel"s. +hen using either b!c< o2 p!c< !nim!ls or *hoballo* (sle"ge) "r!wn usu!ll5 b5 p!ir o2 oDen or in some !re!s some !nim!l "r!wn c!rt, the bun"le o2 crop will be tr!nsporte" to threshing 2iel" c!lle" *awudima* usu!ll5 prep!re" !roun" the homeste!" where it is con1enient 2or loo<ing !2ter. 8un"le o2 whe!t is tr!nsporte" to the ne!rb5 pl!te 2iel" not onl5 2or con1enience but it is bec!use the str!w is highl5 nee"e" 2or 2ee"ing li1estoc< !n" !lso be sol" 2or house construction purposes both in the town !n" rur!l !re!s. +r!nsport!tion me!ns coul" !lso be hum!n l!bor "epen"ing on the !1!il!bilit5 o2 tr!nsporting !nim!l or "ist!nce o2 the 2!rm 2iel" 2rom the threshing pl!te. +hen crop bun"le will be st!c<e"or he!pe" !g!in 2or sometimes or m!5

"irectl5 be threshe" !n" this will "epen" on nee" 2or the gr!in either 2or home consumption or m!r<et purpose, !1!il!bilit5 o2 !nim!ls 2or tr!mpling !n" we!ther con"itions suit!bilit5 2or threshing !cti1it5. +hen the 2iel" will be cle!ne" o2 gr!sses !n" other m!teri!ls !n" the crop will be threshe" !n" the str!w is winnowe", cle!ne", me!sure" !n" tr!nsporte" to the gr!in stor!ge or w!rehouse sometimes.

. !ch !cti1it5 is !ccomplishe" b5 hum!n being m!nu!ll5 using 2!mil5 l!bor or other w!ge" l!bor. - ccor"ing to "!t! collecte" using 2ocus group "iscussion !n" chec<list, h!r1esting (sic<ling) is usu!ll5 "one b!se" on contr!ct b!sis !n" the cost is between 1800 . +8 !n" 2000 . +8 b!se" on crop "ensit5 while it too< 1# to 20 m!n-"!5s to h!r1est ! hect!re o2 whe!t. Eor this rese!rch purpose !1er!ge o2 the m!Dimum !n" minimum 1!lues which w!s 18m!n"!5s w!s consi"ere" to compute the comp!r!ti1e !"1!nt!ges o2 "i22erent threshing mech!nisms. . 1en though on 2iel" he!ping is "one b5 h!r1esting l!borers, 2or this consumption, the l!bor nee"e" 2or he!ping w!s c!lcul!te" !n" on !1er!ge 0.=5m!n"!5s per hect!re w!s re@uire" while 0.=m!n"!5s w!s nee"e" !t tr!mpling pl!te. - roun" 3 er!ro (- s, bun"le tr!nsport!tion is "one usu!ll5 on b!c< o2 p!c< !nim!ls (horse !n" "on<e5) while sle"ges ("r!wn b5 p!ir o2 oDen) !n" horse "r!wn c!rts were use" !roun" Cemu-"im! (- . 1en though it is not common !roun" Cemu-"im! (- !nim!l renting 2or whe!t crop tr!nsport!tion !n" tr!mpling w!s common !roun" (- s o2 3 er!ro (one o2 the sites this rese!rch w!s con"ucte") !n" it w!s !"!pte" 2or Cemu-"im!:s !re! !n" use" !s proD5 !n" the !1er!ge rent!l price o2 #0. +8/!nim!l "!5 w!s use" 2or comput!tion. 3 ost 2!rmers in the stu"5 !re! <eep l!rge number o2 horses !n" oDen 2or tr!mpling purposes 2or short perio" o2 time !n" some other 2!rmers rent !nim!ls 2or tr!mpling purposes.

Eor comput!tion o2 this rese!rch wor<, the wi"el5 use" b!c< o2 p!c< !nim!ls; "on<e5 !n" horse w!s use".)n !1er!ge to tr!nsport ! hect!re o2 crop bun"le 15 "on<e5 "!5s !n" 20 m!n-"!5s were use".)ption!ll5 one c!n !lso use contr!cting out o2 he!pe" bun"le !n" hect!re o2 crop w!s usu!ll5 he!pe" !t 2our pl!ces !n" e!ch he!p costs !bout 1200 . 8 * to tr!nsport to threshing plot. - 1er!ge cost o2 hiring ! "on<e5 "!5 is '5 . 8 */"!5.

4.2.2. Combine Harvesting Method

$n some pl!in o2 - rsi !n" 8!le combine h!r1esting is commonl5 use" !n" subst!nti!ll5 re"uces l!bor 2or whe!t pro"uction !n" !gricultur!l "ru"ger5 !s ! whole. 3 ost

2!rmers in these !re!s pre2erre" the pro"uction o2 whe!t o1er other crops bec!use o2 its e!se o2 pro"uction especi!ll5inwee"ing !n" h!r1estingprocesses. $n ; etos! more th!n =' G o2 the respon"ents use combine h!r1ester while it is onl5 !roun" 2#G in Cemu-bilbilo which is m!inl5 "ue to the incon1enience o2 topogr!ph5 in the !re!.

$n pre1ious time there were "i22erent sources o2 combine h!r1esters rent ser1ices li<e -gricultur!l 3 ech!ni7!tion %er1ice %t!tions, pri1!te owners, st!te 2!rms, 2!rmers !n" !gricultur!l "e1elopment eDperts tr!ining centers li<e -r"!5t!, !n" etc. 8ut currentl5 the m!r<et is "omin!te" b5 pri1!te owners !n" in some !re!s li<e ; etos!, unions !re pro1i"ing combine rent ser1ices. 0!lem! union !lso st!rte" combine h!r1esting ser1ice pro1ision with two combine h!r1esters. %er1ice pro1i"ers !re mo1ing 2rom pl!ce to pl!ce !n" their wor<ing !re!s !re not boun"e". +he5 usu!ll5 mo1e 2ollowing the crop m!turit5 c!len"!r 2rom e!st %hew! to 8!le 7ones. +hreshing/h!r1esting st!rts in -s!s! 2rom mi"-)ctober !n" continues while in ; etos! it st!rts 2rom &o1ember. $n some highl!n"s o2 Cemu-bilbilo !n" others it will continue up to F!nu!r5.

Hiel" estim!tion is "one b!se" on weight b!sis b5 oper!tors !n" ! @uint!l is e@ui1!lent to 100<g while 2!rmers me!sure their gr!in 5iel" !2ter re-cle!ning using ! pol5eth5lene b!g which cont!ins 115 to 120 <g which the5 consi"ere" !s one @uint!l. %ometimes this "i22erence which is cre!te" bec!use o2 misun"erst!n" bec!me source o2 "ispute !n" loss o2 trust between oper!tors !n" 2!rmers. +here2ore, 2or this comput!tion purpose, the 5iel" me!sure b5 2!rmers !2ter re-cle!ning w!s !" uste" b5 the !1er!ge o2 the "i22erence between the two me!surements. ;ence, the !" uste" 5iel" w!s use" to c!lcul!te the gross return !n" cost o2 h!r1esting. +he !" ustment 1!lue w!s t!<en to be 1'.5<g (i.e. ! @uint!l o2 5iel" me!sure b5 2!rmers !2ter re-cle!ning w!s consi"ere" to be 11'.5<g).

*e-cle!ning o2 the combine h!r1este" gr!in re@uires 0.08 m!n-"!5s per @uint!l which is !roun" 4.5=.+8/@t b!se" on current w!ge in the stu"5 !re!where comp!r!ti1e !ssessment

o2 engine-"ri1en st!tion!r5 thresher 1is-9-1is m!nu!l threshing w!s con"ucte" (#0.+8/"!5). >!il5 l!borer:s w!ge w!s !roun" "ouble in ; etos! "uring the s!me perio" !n" one c!n simpl5 obser1e th!t how computing with the two l!bor intensi1e mech!nisms in the !re! is too tough in this !re!.-2ter re-cle!ning, the gr!in will be p!c<e" !n" tr!nsporte" to home b5 !nim!l "r!wn c!rt or p!c< !nim!l !n" on !1er!ge it costs !roun" 5.+8 per @uint!l !n" this cost is common 2or !ll the three threshing metho"s.

/ost o2 combine h!r1esting inclu"es hire o2 combine h!r1ester, tr!nsport with tr!iler, l!bor 2or re-cle!ning !n" in most c!ses tip 2or oper!tor. 8ut since tip 2or oper!tors is not leg!l !n" it is not uni2orm throughout, some 2!rmer p!5 while the other were not p!5ing, it w!s "i22icult to estim!te !n" w!s not inclu"e" in the cost.

Table 2. *Households' use status of tractor and combine harvesting machines.*

Mechanization technology	User	Non-user
+r!ctor	4#(38.33)I	'4(#1.#')
/ombine h!r1ester	4'(3=.2)	'3(#0.80)

I&umber in p!renthesis is percent!ge

4.2.3. Performance of AsellaModel-3 Multi-crop Thresher

)n 2!rm pr!ctic!l p!rticip!tor5 per2orm!nce e1!lu!tion o2 -sell! mo"el-3 multi-crop thresher w!s con"ucte" in Cemmu-8ilbilo "istrict !t three sep!r!te sites. +wo pe!s!nt !ssoci!tions ((-s were selecte" b!se" on their whe!t pro"uction potenti!l !n" !ccess to "i22erent threshing mech!nisms. +hree willing 2ull 2!rmers were selecte" 2rom the two (-s 2or eDperiment. +wo e@u!l whe!t crop 2iel"s (0.125h! e!ch) were prep!re" !t e!ch site !n" r!n"oml5 !ssigne" to tr!"ition!l (!nim!l tr!mpling !t *hogdi/awudima*) !n" -sell! mo"el-3 engine "ri1en st!tion!r5 threshing m!chine metho"s. +he crop w!s 2irst h!r1este" b5 sic<le !n" tr!nsporte" to threshing 2iel"s: o2 respecti1e 2!rmers. +he threshing m!chine w!s oper!te" !t optimum oper!tion spee" o2 !1er!ge "rum spee" '8#.#'*(3, !n" !1er!ge 2un spee" o2 1450*(3. Euel consumption w!s c!lcul!te" to be 1.2litters per hour.

Table 3. *Machine Vs traditional method performance comparison for different parameters.*

	Grain-straw ratio(wt/wt)	cleaningefficiency	Threshingcapacity	yield/ha (thresher)	yield/ha (traditional)	yield/ha (combine)
%ite1	2:1	85.835	3.#@t/hr	30	24.5'	24.53
%ite2	1.8'5:1	85.355	4.5@t/hr	35	30	42.'#
%ite3	2:1	=4	2.5@t/hr	18.'	1#.=2	2'.81
	-	-	-	-	-	20.#0
-1er!ge	1.=58:1	88.40	3.53	2'.=0	23.83	2#.1'

Erom t!ble 3 !bo1e, it re1e!le" th!t the m!chine (-sell! mo"el-$$$ engine "ri1en thresher) threshes 3.53 @uint!ls (353<g) o2 whe!t per hour while the !1er!ge cle!ning e22icienc5 w!s !bout 88G which is out o2 tot!l threshe" output, !bout 12G w!s impurit5.

/osts 2rom h!r1esting to tr!nsport!tion were !ll the s!me with th!t o2 tr!"ition!l !nim!l threshing metho"s !n" the

"i22erence is cost o2 threshing !n" cle!ning. %ince the str!w o2 whe!t in -rsi w!s use" !s !nim!l 2ee", the whe!t bun"le h!s to be tr!nsporte" to ne!rb5 pl!te c!lle" *awudima/hogdi* !n" he!pe" 2or some times 2or two m!in re!sons. +he 2irst re!son w!s to "r5 out moisture o2 the str!w 2or e!se o2 threshing !n" the secon" re!son w!s to get time until the5 2inish h!r1esting other crops 2rom their 2iel"s.

Table 4. Man-days requirement for different threshing mechanisms.

		Amount	Cost	Total
6 he!t oper!tion	+5pe o2 C!bor	*e@uire"/h!	per ?nit (8r)	cost/h!
3 !nu!l ; r1esting:				
; !r1esting	; um!n	18	#5	11'0.0
; e!ping in 2iel"	; um!n	0.=5	#5	#1.'5
; e!ping !t threshing plot	; um!n	0.=0	#5	58.50
+r!nsport!tion	; um!n	20	#5	1300.0
+r!nsport!tion	>on<e5	15	'5	1125.0
+hreshing	; um!n	=	'0	#30.00
+hreshing	- nim!l	45	#5	2'00
6 innowing !n" b!gging	; um!n	#	#5	3=0.00
+r!nsport!tion (gr!in)	Cump sum	5	11=.15	
%t!tion!r5 .ngine >ri1en +hresher +hreshing 3 etho":				
; !r1esting	; um!n	18	#5	11'0
; e!ping in 2iel"	; um!n	0.=5	#5	#1.'5
; e!ping !t threshing plot	; um!n	0.=	#5	58.50
+r!nsport!tion	; um!n	20	#5	1300
+r!nsport!tion	>on<e5	15	80	1125
3 !chine cost	3 !chine	1	355.'5	
Euel cost	Euel	1.2lit	1#.1#	153.3
) per!tor	; um!n	3	#5	1=2.'0
6 innowing	; um!n	0.08/@t	#5	145.1
+r!nsport!tion (gr!in)	Cump sum	5	13=.5	
+ot!l 1 !ri!ble cost 2or engine "ri1en threshing mech!nism				4'01.#

4.3. Financial Profitability Analysis of the Mechanisms

+o comp!re 2in!nci!l pro2it!bilit5 o2 the three threshing mech!nisms, tr!"ition!l m!nu!l h!r1esting !n" !nim!l tr!mpling, m!nu!l h!r1esting !n" st!tion!r5 engine "ri1en m!chine threshing !n" combine h!r1esting techni@ues, p!rti!l bu"geting w!s emplo5e" (+!ble 5). Eor the two threshing mech!nisms (m!nu!l !n" motori7e" thresher) e1en though threshing/h!r1esting cost per @uint!l is "i22erent !s gr!in 5iel" per @uint!l is "i22erent 2or the two threshing mech!nisms, since the crop h!s to be h!r1este" 2irst using sic<le, the5 both sh!re s!me !ll costs 2rom h!r1esting to tr!nsporting to threshing 2iel"s.

Table 5. Financial profitability (Birr/ha) of wheat harvesting and threshing technologies in Arsi (Lemu-bilbilo district).

	ManualHarvesting	ThresherHarvesting	CombineHarvesting
Hiel" (@t/h!)	23.83	2'.=0	2#.1'
0ross return[1]	20255.55	23'15	245=0.50
/ ost o2 m!nu!l h!r1esting:			
C!bor 2or ; !r1esting	11'0	11'0	-
C!bor 2or ; e!ping	120.25	120.25	-
C!bor 2or +r!nsport!tion[b]	1300	1300.0	-
C!bor 2or +hreshing[c]	1200	-	-
C!bor 2or winnowing[d]	#30	-	-
- nim!l l!bor[e]	3825	1125	-
3 !teri!l cost	58.'5	58.'5	-
C!bor 2or oper!tion	-	1=2.51	-
C!bor (re-cle!ning !n" weighing)	-	145.08	-
3 !chine cost[2]	355.50		
/ ost o2 combine h!r1esting (. +8/h!)			
; ire o2 combine h!r1ester	1'31.#0		
+r!nsport with tr!iler	288.#0		
C!bor (re-cle!ning !n" weighing)	13#.08		
+r!nsport with c!rt/"on<e5	130.85		
+ot!l costs th!t 1 !r5	8304	4##'.0=	228'.13
&et income !2ter 1 !r5ing cost	115=1.55	1=24'.=1	1==5'.3'

[1] !er!ge price o2 850 . +8 per @uint!l w!s t!<en ("!t! 2rom 2!rmers !n" > -s)
[b] 2or tr!nsport!tion o2 whe!t bun"le, 1.33 m!n-"!y5 is nee"e" per ! "on<e5 (20m!n-"!y5s 1s 15 "on<e5 "!y5s)
[e] !nim!l l!bor 2or m!nu!l threshing inclu"es !nim!l 2or threshing !n" tr!nsporting bun"les 2rom 2iel" to !w"im! while in motori7e" thresher c!se it inclu"es onl5 !nim!l l!bor 2or tr!nsport!tion
[2] *e2er - ppen"ices $ J $4 2or m!chine cost comput!tion

) wn combine h!r1esting !t sm!ll sc!le 2!rming le1el li<e th!t o2 .thiopi! is unthin<!ble there2ore, cost o2 h!r1esting b5 combine h!r1ester w!s c!lcul!te" b!se" on cost o2 hiring the m!chine on @uint!l b!sis. $n some c!ses, when the oper!tors percei1e" th!t l!n" pro"ucti1it5 o2 speci2ic 2!rm is not goo", the5 pre2er to cost b!se" on l!n" si7e. 8ut since this h!ppen in r!re c!ses, onl5 cost per @uint!l b!sis w!s use" 2or this p!rticul!r rese!rch.

Eor motori7e" st!tion!r5 engine "ri1en threshers, since owing the m!chine !t le!st in group b!sis is possible, the threshing cost i2 the m!chine w!s owne" w!s c!lcul!te". /ost o2 threshing in this c!se inclu"es m!chine owing costs, m!chine oper!ting cost, !n" h!r1esting !n" tr!nsport!tion costs.

Table 6. *Cost and returns of machine per a year.*

Cost item	quantity	unit price	total cost
+ot!l l!bor cost	3(>I#58r/"!5I25"!5s	#5	48'5/5e!r
Euel cost	1.2lit/hrsI200hrs	1#.1#	38'8.4/5e!r
+ot!l 1!ri!ble cost			8'53.4.+8/5e!r
+ot!l m!chine owing cost/5e!r (200hrs)	45I200hrs	=000.00	
+ot!l o1er!ll cost per 5e!r			1','53.4.+8
0ross !nnu!l return	'0#@t	55.+8/@t	38,830
&et income per ! 5e!r			21,0'#.#0

/urrentl5 2!rmers who bought engine "ri1en multi-crop threshing m!chine 2rom - sell! - .*/ !re renting ! m!chine 2or 55.+8 per ! @uint!l !n" m!chine owners onl5 suppl5 m!chine oper!tor (one person-"!5 per ! m!chine). +he gross return per ! 5e!r 2rom m!chine rent will be 3.53@t/hrI200hrs/5e!rI55.+8/@t which is e@u!ls to 38,830.+8.+he net income 2rom the rent o2 threshing m!chine will be the "i22erence between gross return !n" tot!l o1er!ll cost per 5e!r !n" it is 21,0'#.#0.+8 per 5e!r. +here2ore, i2 one bu5 !n" rent ! m!chine the m!chine p!5-b!c< perio" will be !roun" two !n" h!l2 5e!rs.

%ensiti1it5 !n!l5sis o2 the in1estment shoul" be !ssesse" !t three st!ges, un"er norm!l, interme"i!te !n" worst scen!rios. $n this c!se the worst scen!rio coul" be when the ser1ice ch!rge is re"uce" to ch!rges e@ui1!lent to combine h!r1esting ch!rges gi1en !roun" .the5! !n" 0e"eb-s!s! "istricts where topogr!ph5 is more suit!ble 2or combine h!r1esting !n" there is l!rge suppl5 o2 ser1ice. $n these !re!s, the hiring ser1ice m!r<et is !t competiti1e b!sis !n" the ch!rge "uring perio" w!s 40.+8 per @uint!l.+here2ore, i2 the ser1ice ch!rges o2 engine "ri1en whe!t thresher re"uce to 40.+8/@uint!l, the net income will be re"uce to 1=,48#.#0.+8 !n" the p!5-b!c< perio" will be !roun" two 5e!rs.

4.4.2. Internal Rate of Return (IRR) for Asella Model-III Multi-crop Thresher

Table 7. *Machine Investment Cash Flow.*

Year	Cash Flow	Amount (ETB)
He!r 0	(in1estment)	-4',000.00
He!rs 1-10	210'#.#0/5e!r	
$**	44G	

4.4. Economic Advantages of Wheat Threshing Mechanisms

4.4.1. Machine Payback Period and Sensitivity Analysis

- m!chine p!5-b!c< perio" is ! consecuti1e time in ! m!chine:s eDpecte" economic li2e th!t ! m!chine:s purch!se price coul" be re-g!ine 2rom its ser1ices. $t w!s !ssume" th!t one hum!n "!5 is e@ui1!lent to eight hours wor<ing !n" three hum!n "!5s w!s nee"e" to wor< on ! m!chine. - m!chine w!s estim!te" to wor< 2or !bout 200hrs !n c!n thresh ! tot!l o2 !bout '0# @uint!ls o2 whe!t per ! 5e!r. C!bor to thresh this !mount o2 whe!t w!s three person-"!5s per ! "!5 times twent5 2i1e (i.e. i2 ! m!chine wor<s 2or 2ull-time which is 2or eight hours, it too< 25 "!5s in ! 5e!r to wor< 2or tot!l o2 200 hours) "!5s (+!ble #).

+he $ntern!l r!te o2 return ($**) 2or !n in1estment is the percent!ge r!te e!rne" on e!ch birr in1este" 2or e!ch perio" it is in1este". 3 !them!tic!ll5, intern!l r!te o2 return ($**) is the interest r!te !t which the net present 1!lue o2 !ll the c!sh 2lows (both positi1e !n" neg!ti1e) 2rom ! pro ect or in1estment e@u!l 7ero. $n this c!se it is the $** 2or in1estment on the) - *$--sell! mo"el-$$$ multi-crop thresher. +he c!sh 2low inclu"es initi!l in1estment !n" the net income 2rom the rent o2 m!chine 2or the neDt consecuti1e ten 5e!rs. +he result re1e!le" in +!ble ' th!t the intern!l r!te o2 return 2or the m!chine w!s 44G which is much higher th!n the interest p!i" on s!1ing b5 commerci!l b!n<s. +his !mount is !lso b5 2!r gre!ter th!n the lo!n interest r!te (1'G) le1ie" b5 2in!nci!l institutions li<e) romi! /re"it !n" %!1ing - ssoci!tion (6-CK) !t ! time this stu"5 w!s con"ucting.

4.5. Need Assessment for Willing to Use Asella Model-III Multi-crop Thresher

%imple !ssessment w!s con"ucte" on 2!rmers who !tten"e" "uring e1!lu!tion o2 the m!chine !t Cemu-8ilbilo "istrict !n"others who were not there "uring e1!lu!tion but <nows !bout - sell! multi-crop thresher both in ;etos! !n" Cemu-bilbilo through @uestionn!ires were 2ille" to 2in" i2 the5 were willing to use the m!chine !n" i2 the5 !re willing, the mo"e o2 owning the m!chine. -ccor"ingl5, !ll the p!rticip!nts were willing to use the m!chine either through bu5ing in group or through renting. *espon"ents 2rom ;etos! "istrict pre2erre" the m!chine !s !n option !n" 2or some poc<et !n" in!ccessible plots while those in Cemu-bilbilo "istrict; the m!chine un"er e1!lu!tion w!s the onl5 choice to mech!ni7e their 2!rm !t current situ!tion.

 - roun" 28G (34 out o2 120) o2 2!rmers were willing to bu5 the m!chine in group while !roun" #=G (4' out o2 #5) o2 them were willing to use in rent!l b!sis !n" !roun" 3G were willing to bu5 the m!chine in"i1i"u!ll5.

5. Conclusion

Eor this rese!rch !cti1it5 "!t! w!s gener!te" in two w!5 n!mel5 sur1e5 t5pe !n" on 2iel" economic e1!lu!tion o2 the three threshing mech!nisms (combine h!r1esting, engine "ri1en st!tion!r5 multi-crop thresher threshing !n" m!nu!l threshing). 0ener!ll5, the result o2 sur1e5 re1e!le" th!t in - rsi 7one, whe!t 2!rm is the most rel!ti1el5 mech!ni7e" enterprise speci!ll5 in "istricts loc!te" on m!in ro!" 2rom - "!m! to 8!le !n" h!1e con"uci1e topogr!ph5 2or l!rge !gricultur!l m!chineries n!mel5 tr!ctor !n" combine h!r1ester. $n ; etos!, one o2 the most !ccessible "istricts in - rsi 7one, more th!n =0 percent !n" '5G o2 the househol"s were using combine h!r1ester !n" tr!ctor 2or whe!t pro"uction respecti1el5. Eor those in!ccessible !re!s, the most "omin!ntl5 use" whe!t threshing mech!nism w!s m!nu!l sic<ling !n" !nim!l tr!mpling mech!nism. +he st!tion!r5 engine "ri1en threshing mech!nism w!s !t popul!ri7!tion st!ge b5 ministr5 o2 !griculture !n" - sell! !gricultur!l engineering rese!rch center. +he center rele!se" its: thir" mo"el thresher which h!s o1er!ll per2orm!nce o2 3.53@t/hour threshing c!p!cit5 !n" 88.4 percent cle!ring e22icienc5. / ost o2 threshing were 228'.13, 4##'.0= !n" 8304 . +8 2or combine h!r1esting, engine "ri1en thresher !n" m!nu!l h!r1esting mech!nisms while the net income !2ter 1!r5ing costs were 1==5'.3', 1=24'.13 !n" 115=1.55 . +8 respecti1el5. +he p!5b!c< perio" 2or engine "ri1en st!tion!r5 threshing m!chine w!s c!lcul!te" to be !roun" two !n" h!l2 5e!rs. +he thresher h!s !""ition!l !"1!nt!ge o2 str!w chopping which 2!cilit!tes its: p!l!t!bilit5 2or !nim!tr

Appendix III. Machine and Engine Owing Cost Calculation

Machine	purchase prices (P)	Average life(h)	Average used time/Annum	Salvage value (10%P)	Average Investment cost	Depreciation cost	Insurance	Interest cost
+hresher	2=,000	2000	200	2=00	30450	13.05	0	=.135
.ngine	18000	2000	200	1800	==00	8.1	0	2.='
+ot!l	4',000	4,000	400	4,'00	40,350	21	0	12

Machine	TFC	TFC excluding interest	Repair & maintenance cost as % of purchase price	Repair and maintenance cost	TVC	TC Br/hr	TC excluding interest
+hresher	22.1=	13.05	50G	'.25	'.25	2=.44	20.3
.ngine	11.0'	8.1	50G	4.5	4.5	15.5'	'.4'
+ot!l	33	21	1	12	12	45	28